tech engineering news

February 1952

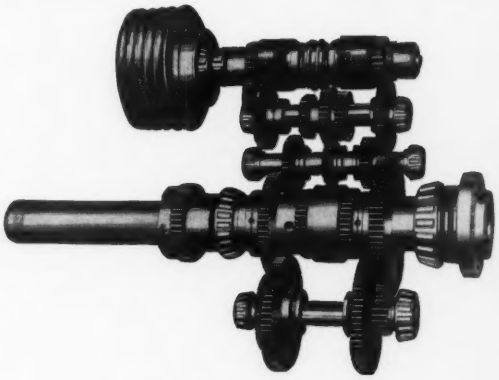
Another page for **YOUR BEARING NOTEBOOK**

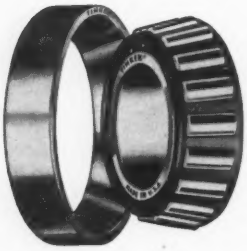
For high-precision gear trains TIMKEN® bearings are just the ticket

Shaft deflection or end-movement in a lathe gear train causes inaccurate meshing of gears, excess wear and loss of precision. So to insure shaft rigidity, leading machine tool designers specify Timken® precision bearings for spindles and other shafts. Due to their tapered construction, Timken tapered roller bearings carry thrust and radial loads in any combination. Shafts are held in proper alignment. Accurate meshing of gears is assured.

How to mount tapered roller bearings in a lathe head

The two single-row Timken precision bearings on the spindle are mounted indirectly. On the spindle end, the cones are pressed to the spindle shoulder. The bearing on the opposite end is backed by a collar, gear and nut. A two-row, indirectly mounted bearing is used on the pulley end of the input shaft. The remaining Timken bearings are directly mounted, and shim-adjusted.





TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

How you can learn more about bearings

Some of the engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about this phase of engineering, we'll be glad to help. For a copy of the 270-page General Information Manual on Timken Bearings, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL ◐ AND THRUST —◎— LOADS OR ANY COMBINATION ✳

To keep plant operating costs down to earth

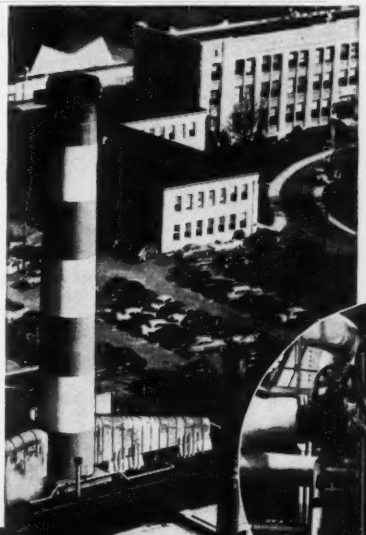
To fulfill its tremendous task of building engines and other aircraft components for defense and civilian needs, United Aircraft Corporation is in an almost continuous state of expansion.

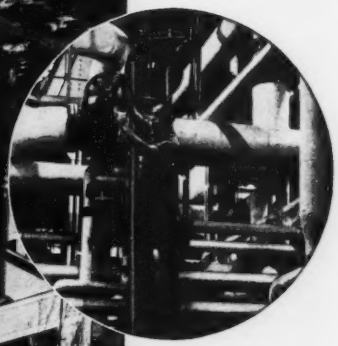
An addition to the power house at the main plant in East Hartford (below) has recently been completed. The $12,000,000 Andrew Willgoos Turbine Laboratory was finished and put in operation on jet research in the past year. Under construction are new plant facilities at the Pratt & Whitney Aircraft Division in North Haven, and the Hamilton Standard Division in Windsor Locks, Conn.

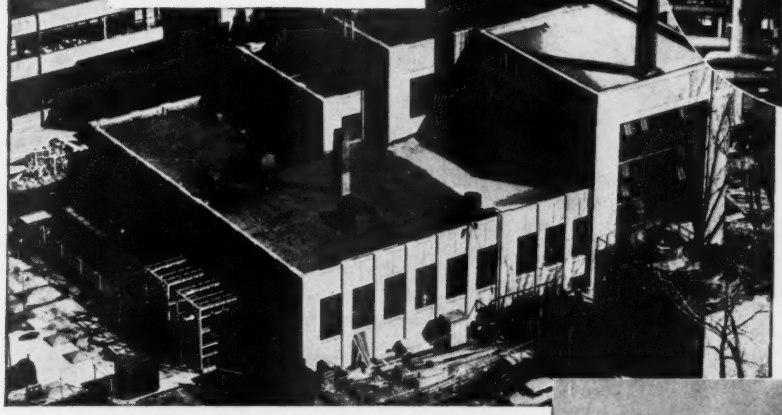
When it comes to plant operation, United Aircraft is right down to earth. To make sure of lasting efficiency and low maintenance in fluid control, they chose Jenkins Valves for all of these new buildings. At the right is a typical valve station in the vast network of piping at the Willgoos Laboratory.

Long a leader in the development and production of piston engines, notably the famed Wasp, the Pratt & Whitney Division is now a major producer of jet engines like the J-48 Turbo Wasp that powers the Navy's new Grumman Panther, shown above.

Design Engineers:
ALBERT KAHN ASSOCIATES, DETROIT, MICH.
General Contractors:
THE WADHAMS & MAY COMPANY, HARTFORD, CONN.
Piping Contractors:
THE LUMSDEN & VAN STONE DIVISION
MIDWEST PIPING & SUPPLY COMPANY, INC., BOSTON, MASS.







United Aircraft Corporation relies on

On their low upkeep cost record, Jenkins Valves are being specified for more and more of the new industrial plants, the modern commercial, institutional, and municipal buildings that are setting new standards in operating efficiency.

Despite their *extra* value, proved in every type of service, *builders pay no more* for Jenkins Valves. That's why, for new installations, for all replacements, the Jenkins Diamond is their reliable guide to lasting valve economy. Jenkins Bros., 100 Park Ave., New York 17, Jenkins Bros., Ltd., Montreal.

JENKINS VALVES
LOOK FOR THE DIAMOND MARK
SINCE 1864
TRADE JENKINS MARK
Jenkins Bros.

SOLD THROUGH LEADING INDUSTRIAL DISTRIBUTORS EVERYWHERE

"Daddy...draw me a Freedom"

"Susie thinks I'm Rembrandt.

"She's not too bad at drawing cows or moons or pumpkins. But every time she hears a new word, she expects *me* to draw it for her. She doesn't take *no* for an answer . . . so, for 'Freedom,' I drew her an American Flag and she was satisfied.

"Later I thought: how *else* can you describe a word like 'Freedom'? For instance . . .

"When a churchbell peals in America, it rings Freedom. Every time we mark a ballot, it votes for Freedom. Each paycheck I get from Republic Steel is drawn on Freedom. Our newspapers have a rustle of Freedom to them.

"Freedom is a major subject in every good American School: The auto you drive is a deluxe Freedom model. All radio and TV sets are tuned in to Freedom. And every cop pounds a beat on Freedom Street . . . in America.

"Sure, *we* like Freedom, and some governments abroad *don't*. But . . . watch out for the home-grown commies, socialists and hate-mongers among us who are trying to get us to turn our Freedoms over to the 'State.' Watch out, too, for wasteful splurging of public funds by the government . . . federal, state and local, alike. This is one sure shortcut to the loss of our personal Freedoms.

"Y'know, our fathers passed along to *us* a pretty wonderful country . . . with all the important Freedoms included. Wouldn't we be pretty poor parents if we, in turn, handed over a socialistic, bankrupt America to *our* kids?"

REPUBLIC STEEL

Republic Building, Cleveland 1, Ohio

Republic BECAME strong in a strong and free America. Republic can REMAIN strong only in an America that remains strong and free . . . an America which owes much of its progress to the men and machines of its countless industries. *And through these industries, Republic serves America.* A good example can be found in the Roadbuilding Industry, responsible for the more than three million miles of highways that crisscross our nation from border to border and coast to coast. *Steel* earthmovers pave the way, followed by graders, mixers, forms, roadbed wire mesh, drainage pipe, guard rails . . . the list is long. All products of *steel*, much of which comes from the mills of Republic.

* * *

For a full color reprint of this advertisement, write Dept. H, Republic Steel, Cleveland 1, Ohio

The Westinghouse Plan

...to help you get set Right

A straight line is the shortest distance in careers, too. At Westinghouse we assume the responsibility of defining that line clearly for college graduates who join us. Only in that way can you get set right, avoid costly trial and error procedure . . . and achieve surer success.

With the Westinghouse Plan, you start an orientation program at the new Educational Center. Here, you learn about Westinghouse, its products and operation. You make new friends and contacts that last through the years.

This is followed with basic training, where you learn industry and industrial organization and have an opportunity to see the many fields of endeavor and diverse careers open to you at Westinghouse . . . in research, engineering, manufacturing and application.

In a short time, you gain a clear understanding of business and industry from top-ranking men in their fields . . . and have the benefit of personal counsel in selecting the field for your career.

For more details about the Westinghouse Plan for college graduates, send for our 32-page booklet—"Finding Your Place in Industry".

G-10171

The new Westinghouse Educational Center was designed to meet the full requirements of an industry training program. Auditorium, classrooms, magazine and study rooms, plus recreation and hobby rooms . . . darkroom for photographers, radio center for hams, billiard, card and game rooms.

EDUCATIONAL DEPARTMENT

YOU CAN BE SURE...IF IT'S

Westinghouse

To obtain copy of "Finding Your Place in Industry", consult Placement Officer of your university, or mail this coupon to:

Mr. R. E. Davis
District Educational Co-ordinator
Westinghouse Electric Corporation
10 High Street
Boston 10, Massachusetts

Name_____

School_____ Year_____

Street_____

City_____ Zone____ State_____

tech engineering news

February 1952
Vol. XXXIII No. 5

Cyclic Analysis 6
By Stanford R. Amstutz, '54

What is the Scientific Method? 7
By Harry F. Davis, G.

Metals Processing Laboratory 8
By Norman R. Gardner, '53

You As an Officer 10
By David L. Klepper, '53

The Atomic Clock 12
By D. F. Shrader

Upper Limit 14
By Rudolph William Preisendorfer, '52

Noble-Young Amplifier Diagram 18

Cover Design by Jan Piotr Kowalski, '52

FRONTISPIECE

Looking Down Massachusetts Avenue from Memorial Drive

Published monthly during the school year at Walker Memorial, Cambridge 39, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology. Entered as second class matter, at the Post Office, June 1, 1920, at Boston, Massachusetts under the Act of March 3, 1879. Copyright 1952 by The Tech Engineering News. Subscription per year $1.75. Foreign $2.50. One copy 25 cents.

cyclic analysis

A Tool of Prediction

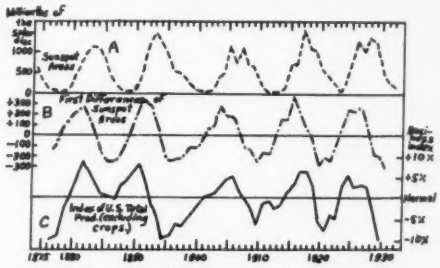
By Stanford R. Amstutz, '54

A great deal of investigation has been undertaken concerning the validity of the use of cycles as a means of predicting economic and natural phenomena. This article shall attempt to outline some of the results so far obtained.

Before we proceed further, it would be well to define a few terms. In what follows below, a cycle denotes a phenomenon which repeats itself. For example, a variation in the price of wheat from high to low and back again would be considered a complete cycle. In this definition nothing is implied concerning the period of succeeding cycles. This is, however, included in the definition of the rhythmic cycle or rhythm. A rhythm then is a cycle that repeats itself at regular time intervals. Now that we've disposed of the definitions, let's get on to some of the surprising correlations that a study of cycles will reveal.

There appears to be a rhythmic cycle of nine and two-thirds years in certain natural phenomena. A plot of data taken from 1880 to 1929 recording the abundance of salmon in the Atlantic Ocean shows that in this period five definite peaks or maxima appeared. The time interval from peak to peak was very nearly nine and two-thirds years in each case. Similarly, in the period 1844 to 1933, records kept of the number of lynx skins brought each year to the Hudson's Bay Company revealed a definite nine-and-two-third-year period. Since the trappers could be expected to work just as hard during good years as bad, this certainly gives an accurate comparison, from year to year, of the number of animals at large. Rhythmic cycles with a period of nine and two-thirds years have also been found in the abundance of tent caterpillars, heart disease in the Northeastern States, and the volume of ozone in the atmosphere. Further definite cycles of regular period have been discovered in the weather, in the emotional life of human beings, in the variation of terrestial magnetism, in solar phenomena (sunspots in particular), in the recurrence of high mortality rates due to pneumonia and influenza, and in the growth of California redwoods. And this enumeration by no means includes all cycles that have been found. Is this just coincidence? We're hardly in any position to say at the present time. It may be that the emergence of a similar nine-and-two-third-year rhythm in the supply of salmon, lynx, and the others named is a matter of chance, but the fact that a rhythm repeats itself year after year certainly indicates something more than mere happenstance.

And the next question: Of what value is this? Knowledge of these cycles in natural phenomena is probably of little further benefit. It is in the field of economics that a study of cycles and cyclic analysis has its greatest potential use.

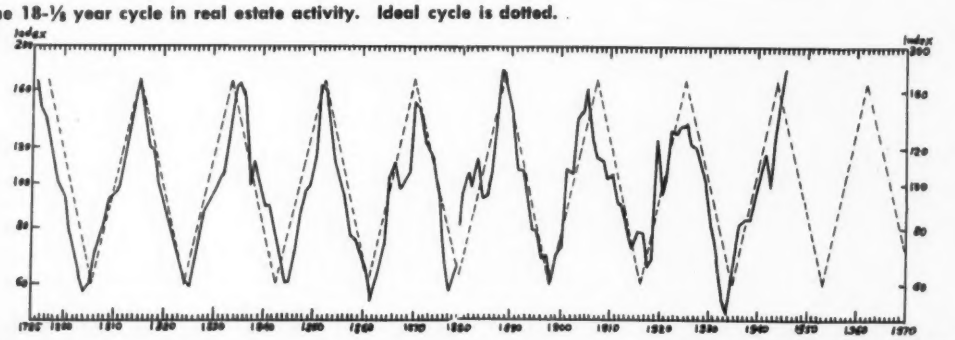


The famous sunspot-business activity "correlation." The solid line represents only industrial production, not crops.

Definite rhythmic cycles have been discovered in the fluctuations of our economy as well as in the natural phenomena catalogued above. However, these economic rhythms are not always as easily distinguished as the above mentioned. This is often due to the fact that two or more rhythms may be interacting on the same system simultaneously. Readers who have had any experience with Fourier analysis are well aware that a curve composed of the sum of a definite number of sine curves of varying phases, periods, and amplitudes looks not at all like any one of its component parts. We find a similar situation when we examine economic curves.

(*Continued on page 20*)

The 18-⅓ year cycle in real estate activity. Ideal cycle is dotted.



what is the scientific method?

The Theory of Cross Structure

By Harry F. Davis, G

An outstanding feature of modern science is the trend towards more abstract theories and greater flexibility in the applications of these theories. The abstract trend tends to produce a more unified body of knowledge, while the numerous techniques that are developed in the applications tend to produce a chaos of methodology. It thus happens that the scientist is often in the anomalous position of having conceptual tools available that are of very wide applicability, and being in such a narrow specialty that none of the tools seem to apply.

Closely related to this situation is the problem teachers face: How can scientific techniques be taught so that the underlying concepts are made clear to the student? There is so much material to be covered, and so little time to do it thoroughly. Should he expose the student to a broad surface of scientific technique, hoping that the underlying ideas will soak in, or should he discuss at length the "scientific method," and run the risk of talking in such generalities that nothing important is said? The new emphasis on humanities at Tech is one solution proposed, the central idea being, presumably, that the study of humanities will help a student to view science and engineering in perspective, so he will not lose sight of basic ideas while in the midst of his formulas. It is an interesting logic that says a student who has "had" a course in the humanities benefits from a broadened viewpoint. Something more basic is needed, something to unify his learning.

Although no ready solutions are in sight, the germ of an interesting approach to scientific concept-structure has appeared. In some respects it is merely a dynamic way of looking at things, as contrasted with the static pictures that dominate much of our thinking. This is a new approach to a better understanding of the scientific method and the art of invention. Although it cannot be fully developed in a short article, especially without the use of elaborate mathematical methods, some comments on it may be of interest to both students and teachers.

Roughly speaking, the idea is the following: In each branch of science and engineering, certain observations have been made, certain data are available, terms have been defined, and relationships observed; all this I refer to as the *structure*. On the existing structure is built a *superstructure*, in a manner to be presently described. This superstructure reflects, in its own properties, many of the properties of the structure that forms its basis. In general, we may have various levels of structure, and even other structures called *dual systems*. The way in which one object shows something about another forms the basis of the theory of *cross structure*.

In some scientific fields, there are fairly well defined strata within the structure, and the great unsolved problems are usually concerned with passing from one strata to another. Examples will be given shortly, and we will see from them that some truly basic logical difficulties may arise in relating one structure with another. In mathematics, these difficulties are concerned with the problem of "choice" when we are dealing with infinite collections. In physics, the notion of causality may be involved in considering the atomic levels, and our ideas of time and space are modified in going to astronomical orders of magnitude.

In order to understand cross structure it is necessary to know something about group theory. Group theory is the oldest branch of mathematics. In Egyptian ornamental tilings there is evidence of considerable knowledge of a group-theoretic nature. Abstract group theory is, nevertheless, fairly new, and much work must yet be done in the theory of groups. This is a theory that is of interest to the scientist and the engineer, as well as to the mathematician. Although it is not widely recognized, some of the basic ideas of second-year physics are of a group-theoretic nature, as will be shown in a following section. In crystallography, groups play an important part in classifying crystals, and of course all branches of geometry, topology, and modern algebra make considerable use of group theory. It is, therefore, at once the most ancient and the most modern of the mathematical sciences, and it can be further claimed to be the one branch of mathematics that is of universal applicability to all sciences. Although some physicists refer to it as the "group pest," its importance is manifest in both relativity (Lorentz Group) and in quantum mechanics. Finally, anyone who has attempted to read Wiener's much-disputed book *Cybernetics* was probably quickly snowed under by lack of knowledge of group theory, unless, of course, he was already familiar with the subject.

Group Theory

The reader is already familiar with most of the groups that will be considered here. An important group is the group of integers, with addition as the "group operation." With any two numbers, say four and seven, it is always possible to associate another number, called their sum. We write $4 + 7 = 11$. Another group is the "group of positive real numbers under multiplication."

A group whose elements are not numbers is the "rotation group." The group elements are rotations about a fixed axis. We "multiply" two rotations by performing them in succession. For example, the product of a rotation by 30° and a rotation by 15° is the rotation by 45°.

Other groups, with which the reader may be familiar, are the vectors, complex numbers, tensors, quaternions, matrices, continuous functions, and permutations, with suitable group operations defined in each case.

In general, the combining operation need not be commutative. That is, ab need not equal ba. For example, pick up a block of wood (or a book) and consider the rotations we describe: Rotate the block of wood 90° about the X-axis, and then 90° about the Z-axis. This does not produce the same effect as a rotation of 90° about the Z-axis followed by a rotation of 90° about the X-axis. That is, rotations do not in general commute.

This is all I will say about the group postulates. I have not given a complete definition, but only some examples. The interested reader should look into one of the standard books on modern algebra.

(*Continued on page 22*)

metals processing laboratory

A New Addition to the M.I.T. Campus

By Norman R. Gardner, '53

There is a fast growing need for engineers who combine a practical knowledge of manufacturing processes with a fundamental understanding of the characteristics of metals. This demand reflects the phenomenal technological advances, largely brought about by the war, on all segments of the industrial front. High compression motors, turbines, and jet propulsion, for example, demand metals which will work at higher temperatures and stresses than present materials can stand, and with closer tolerances than conventional methods can produce.

Furthermore, the mounting pressure of competition calls for the redesign of products and the replanning of manufacturing processes. Often there are economies to be found in the properties of new alloys, or in new developments in casting, welding, hot or cold forming, or powder metallurgy. When it is necessary to increase production with existing machine tool facilities, the answer may lie in utilizing better methods of cutting, and new techniques of inspection.

A combination of mechanical engineering and metallurgical research is sorely needed both to give a solid base to the shop craftsmen and for investigation of new fields. A demand for men who can do this work has led to the establishment of the new Metals Processing Laboratory at M. I. T. It is hoped that this innovation will give a new dimension to the training of engineers and scientists for the metal industries.

The new structure on the corner of Vassar Street and Massachusetts Avenue is expected to be completed, with equipment moved in, by April 1. The dedication is set for some time early in June, and general operations are scheduled to begin this summer. However, a demonstration laboratory has been set up for 3.12 this term.

It should be noted that education in metal processing is not altogether new at the Institute. M. I. T. has been offering training in the principles of manufacturing processes for some seventy years, with the emphasis varying through the decades in step with industrial progress. The recent consciousness of a growing need for broader instruction in the underlying principles of the behavior of metals prompted the Institute to organize, in 1946, an integrated program of metal processing under the joint direction of the Departments of Metallurgy, Mechanical Engineering, and Business and Engineering Administration.

This program is now in operation, and should reach full effectiveness with the opening of this new building, where all related facilities and staff can be brought together. Many subjects, some of which will be discussed below, will be taught and demonstrated in the new laboratory.

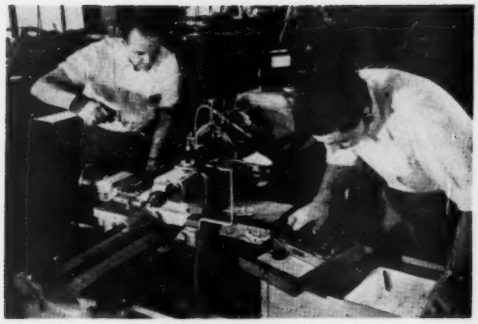
M. I. T.'s present Metals Processing program has already proven to be a successful two-way bridge between theory and practice. For men taking their degrees in Mechanical Engineering, the various required and optional courses in Metal Processing provide a comprehensive understanding of their chief working materials: metals. On the other hand, those majoring in Metallurgy add to their theoretical viewpoint the valuable experience of seeing for themselves what happens to metals under casting, welding, rolling, forging, machine tooling, and other operations. The program was further designed to give students in Business and Engineering Administration an opportunity to secure a solid background in the various kinds of metal fabrication and the possibilities of present and future developments in machine tool practice and metallurgy as keys to higher production and new products.

The sequence of courses relating to metal processing is quite comprehensive. Included within this sequence are such courses as Engineering Metals, 3.11, which is a curriculum dealing with the study of metals and alloys, emphasizing the effect of composition and mode of fabrication on their structure, properties and engineering uses, embracing heat treatment and the fundamentals of constitutional diagrams. Metal Processing, 3.12, follows Engineering Metals with the more practical phase of the field. This course deals with the theory and practice of metal fabricating processes, embracing recent developments in casting, hot and cold forming, and joining. These two courses act as an introductory threshold to the field.

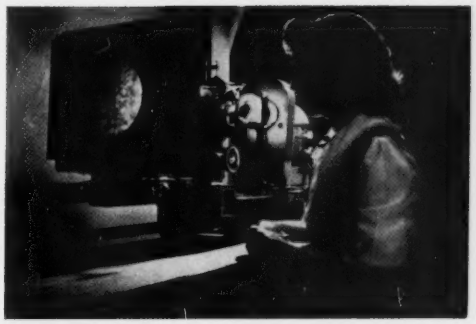
Foundry Engineering, 3.13, is a natural follow-up. 3.13 looks into, in some detail, the theory and modern development of ferrous foundry processes, sizing, grading, and handling of mold materials, flow and solidification of molten metal, heat flow in mold and metal, and gases in metals as related to the production of sound castings. Standard and new methods of molding, melting, alloying, and compressive treatment of casting design are all discussed. The course is designed to stimulate an inquisitive and creative capacity in the student. Besides the scheduled laboratory or plant periods, Professor Taylor allows the men to carry out their own experiments and to operate a full scale experimental foundry on Saturday mornings.

Among the other electives are Welding Engineering, dealing with the joining of metals by brazing, using atomic hydrogen and helioarc. 3.16, Powder Metal-

The new Metals Processing Laboratory.



MIT undergraduates participating in a research project.



Photographing Metallic Structure.

lurgy, a relatively new and promising field, deals with the production of metal powders, their forming, or more properly, pressing and sintering, and their subsequent properties and industrial application.

The formed metal can be investigated further in 3.18, the Mechanical Properties of Metals. This more theoretical program answers, or tries to answer, such questions as the relation between resultant strain produced in a metal piece and applied stress. It tackles such variables as temperature, crystal orientation, prior deformation, fraction point, alloying elements, and numerous others.

The activities to be carried on within the new building are rounded off with excellent courses in Machine Tool Practice and Metal Cutting. Machine Tool Practice deals with the purposes of various tools, their combination in forming finished products, the economics of perfectability, and various design aspects of production.

Although those courses that have been mentioned are essentially all that will be concentrated in the building, the education in metal processing is broadened by complimentary programs in the Institute proper. Such courses as machine design, manufacturing engineering and physical metallurgy all blend into what is believed to be the finest opportunity for education in metal processing that can be obtained anywhere.

In addition to education, research in the metal field is also a major part of the new effort. This research, which is basic to the continual progress and the meeting of pressing needs in the metal fabricating industry, is now in progress. This search into the properties of metals has, in past years, laid greater emphasis on fundamental principles and has thereby greatly augmented the "cut-and-try" methods.

To the scientist, a given piece of steel or aluminum is not merely an object of such-and-such strength and hardness; it is, rather, an assembly of atoms held together as crystals by certain forces. When the basic principles which control the behavior of atoms in metallic crystals are better understood, it will be possible to predict more accurately what will happen under given conditions of stress and temperature, and to forecast the properties of new and untried alloys.

For the past decade a remarkable research program has been carried on with respect to the strength of metals, failure of welded joints, and fracture of metals, to mention a few. More recently, attention has been focused on such pressing problems as the mechanism of plastic flow. Research is also in progress on the cutting process and cutting fluids, distribution of stress in rolling, drilling, grinding, and milling, the nature of friction and wear, and other problems whose solution will have important effects on the manufacturing practices of the future.

All this research, besides making a significant addition to the world's knowledge, serves very well by making the student aware of the present industrial problems, by having him feel himself a part of this effort. Very often undergraduates and certainly graduate students take part in this research activity.

As regards the building itself, it contains five floors, and is divided mainly between the Mechanical Engineering and Metallurgy Departments. The basement is occupied by the Machine Tool Laboratory. Equipment for this laboratory will also be on part of the first floor, which also provides for the instrumentation facilities. The second floor encompasses a great deal of the activity in the fields of metal working and metal cutting. Besides these research and teaching laboratories, the second floor has been provided with a small lecture hall. The main lecture hall will have a capacity of approximately 250 students and will span both the second and third floors. The general administration of the Metal Processing Program will be under the joint supervision of Professors Wulff and Shaw, of the Metallurgy and Mechanical Engineering Departments, respectively. Their offices and others will be located on the third floor along with the bulk of the activity in metallurgy research. The foundry and welding laboratories will be on the fourth floor.

A student-faculty lounge has also been included for the purpose of stimulating better student-faculty relations. It is felt that this addition will aid in the foundation of closely knit groups of men with the common interest in metal processing. As a matter of fact, I'm told some of the professors have volunteered to do some cooking for us, since provisions for this have been made. However, there is still much to be accomplished before full benefit is to be realized.

Alfred P. Sloan's generous gift of one million dollars provided only for the building. Since much of the equipment will not be transferable from scattered portions of the Institute and more and modern equipment will be necessary, there is a real need for more funds. It is hoped that industry will take a further interest in the resources available at M. I. T. by sponsoring projects, by making grants-in-aid, or by providing fellowships. This type of interest has often led to highly promising research.

We have had a significant addition to the M. I. T. educational system, in a field that is now very anxious, and even desperate for information. Indications are that the program at the new Metals Processing Laboratory will be a real success.

you as an officer

By David L. Klepper '53

Should I join the Advanced R.O.T.C.? If I should, which branch? For most of us, the answer to the first question is determined by the international situation, the current Selective Service policy, and its interpretation by our local draft boards. The answer to the second should be determined, but too often isn't, by exactly what we want our service experience to consist of and what the assignment policies of the different branches of the service are.

The M. I. T. student has his choice of six Army units and two courses offered by the Air Force. Although assignments may vary between units, all attempt to assign men where they are best fitted, subject to the current demands of the unit.

An average graduate in the Army Corps of Engineers may expect to spend four or five months training Corps of Engineers enlisted men. This duty will be interrupted by the ten weeks Basic Officers' Course. It is unlikely that he will become a specialist, but can expect to be assigned to a construction or engineering aviation battalion doing road building, base construction, and similar work. The Engineers, being responsible for all Army "real property," encounter a wide variety of construction projects; and it is likely that the officer will obtain considerable experience directing such work. A Reserve Officer on duty with the Corps of Engineers may or may not serve overseas, depending on the international situation.

Signal Corps R.O.T.C. graduates are first sent to Fort Monmouth for the three months Basic Officers' Course. After interviewing, the officer is sent once more to school, this time to one of several advanced technical schools which lead to the five career fields: Wire Communications, Radio Communications, Photography, Procurement and Distribution, and Research and Development. After attendance at one of these schools, the junior officer is assigned to a unit.

The Signal Corps employs civilian engineers; until recently assignments even in the Research and Development Branch have largely been of an administrative nature. Letters from recent graduates indicate that a large number of M. I. T. graduates have now been placed in interesting technical positions. A number are now on duty with a Technical Service Unit at the Signal Corps Engineering Laboratories engaged in classified work in testing. They are now teaching their enlisted personnel communications theory. Other Signal Corps M. I. T. graduates have been assigned to troop duty, but letters indicate they are in interesting and responsible positions.

A Chemical Corps R.O.T.C. graduate first attends a basic officers' course; he then serves three months with a unit training at Fort McClellan. A number of reserve officers then receive assignments in the manufacturing, storage, and distribution branches, or as instructors at Chemical Corps schools. Because of its extensive research, development, and manufacturing programs, the Chemical Corps believes that it gives the M. I. T. graduate great opportunity for employing his knowledge gained here. Officers are needed who are capable of aiding in designing plants for the production of a variety of items, from chemicals to gas masks, as well as engineering the items themselves. Consequently, use is made of electrical engineers, mechanical engineers, and other technically trained individuals other than chemical engineers.

After completion of the three-month basic course at the Ordnance School, the reserve officer may be sent to the Guided Missiles School, to duty with any of the arsenals, including Raritan, Frankford, and nearby Watertown, to a troop training center, to Aberdeen Proving Grounds, or to Europe or the Far East. At an Arsenal he may find himself in one of a number of positions, technical or supervisory; he may or may not do laboratory work depending on the scope of the project. A proof officer at Aberdeen will have the opportunity to use his imagination in recommending changes to weapons undergoing tests. The Ordnance Corps attempts to assign each man where he is best fitted. A few may be assigned overseas.

Upon completion of the Associate Company Officers' Course, Quartermaster Corps officers either receive specialty training or are assigned to a unit. The Quartermaster Corps considers the preferred locality, as well as the background, of the officer. He may serve as a procurement officer at a marketing center, an excellent opportunity for contact with industry, or do research on a variety of products, from refrigerators and plastics to women's clothing.

The requirements for joining the Army Security Agency include, naturally, security clearance, restricting the number who may expect to become part of the Agency. Graduates may go to the thirty or forty-week Communications Intelligence, Traffic Analysis, or Cryptography School at Fort Devens; after which they may do research work for the Agency or be assigned to the Operations Branch. The Army Security Agency recognizes that engineers are at a premium today; an A.S.A. R.O.T.C. graduate may work for the government or for a contractor doing government work as a civilian, yet receive credit for belonging to the Organized Active Reserves.

Considerable information on membership in the Reserves was provided by an interview with a noted Boston contractor who is a Colonel in the Organized

Reserves, Corps of Engineers. He believed that his personal service experience was most valuable to him in his civilian occupation, that the Army offers junior officers considerably greater responsibility than is offered college graduates in industry. Industry needs men who have had leadership experience; consequently, time spent on active duty and in Reserve activities cannot be considered wasted but may be more valuable than equivalent time spent in industry.

Before graduation, each Air Force R.O.T.C. student is interviewed by the Air Science Department. His hobbies, civilian experience, course of study at the Institute, and his desires will all be taken into consideration in determining a career field for him. These career fields include atomic energy, intelligence and psychological warfare, technical liaison with industry, security investigation, weather, communications and electronics, armament, maintenance engineering, and many others. After graduation the newly-commissioned officer will be ordered to active duty with that Air Command having a need for an officer with his career field. These commands include the Air Materiel Command, Research and Development Command, Air Training Command, and others.

The new officer will first receive approximately five weeks of orientation training, after which he will be assigned to a base within that command. Certain officers may first be given further training at civilian colleges or service schools; these are officers in highly technical occupational fields, for example, armament and atomic energy.

Recently, the majority of graduates have been assigned to the Research and Development Command. This command is of comparatively recent origin; it is the result of studies made to provide adequate research and development for the long term strength of American Air power. Because of its rapid growth, M. I. T. men can fill the pressing need of this Command for technically trained officers.

The work of Research and Development is divided among several field commands, including the Cambridge Research Center and the Wright Air Development Center. The positions of Air R.O.T.C. graduates assigned to these field commands have ranged from laboratory work on vacuum tubes to Aeronautical Engineering. Other field commands include the Rome Air Development Center, the Air Force Missile Test Center, the Air Force Flight Test Center, and the Air Force Armament Test Center. The graduate assigned to any one of these field commands will probably do work closely connected with his courses at M. I. T.; in any case the knowledge he gains will be of value to him in industry.

R.O.T.C. Cadets study the intricacies of a Radio Relay Receiver at Ft. Monmouth

There have been and are a number of M. I. T. graduates who have entered or intend to enter the Regular Army or Air Force. These may be distinguished military students or Reserve officers on tours of duty leading to a regular commission. In certain cases these regular officers receive different assignments than Reserve Officers; the Corps of Engineers offers all regular officers increased opportunities for education at government expense, but these officers also usually serve a tour of duty with the Combat Engineers. In other cases assignment patterns may be the same; the Air Force offers all officers, regular and reserve, education leading to a doctor's degree, providing the officer agrees to serve two, three, or four years after receiving the degree. Most other units have similar programs for regular officers. Although in the combat arms the trend for regular officers is away from specialization, the trend in the technical services is definitely toward leaders with technical training.

M. I. T. Junior tests wire line construction at Signal Corps, summer camp.

the atomic clock

A Universal Standard of Frequency and Time

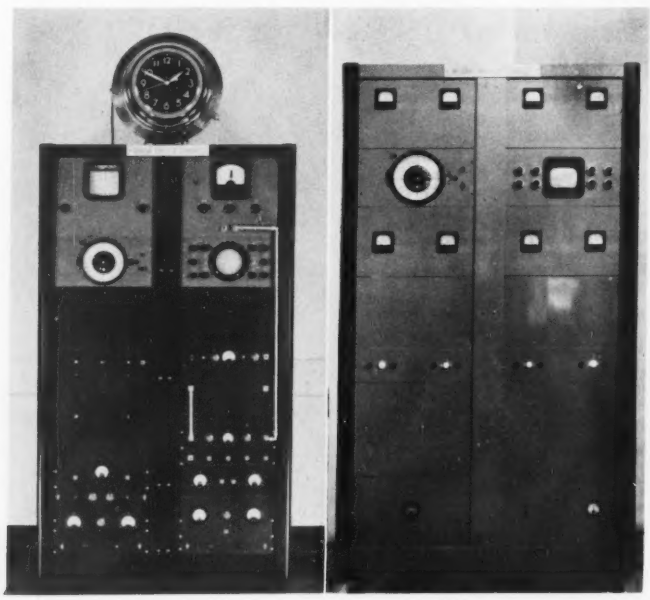
By D. F. Shrader

From material supplied by the National Bureau of Standards

Until recently, our standards of time have all been based on the period of rotation of the earth. This is natural; the earth, being a massive sphere spinning in free space, should whirl at a very constant rate. This is essentially true, but in relatively recent times it was discovered by astronomical measurements that the spin of the earth is not absolutely constant, but undergoes fluctuations on which is superimposed a gradual slowing down. The slowing down is attributed to the dissipation of energy occurring in tidal friction, and perhaps also in friction between the earth's crust and its molten inner core. The fluctuations have not been explained, but they are comparatively large, being of the order of magnitude of one part in twenty-five million. This is so great that a depression of the entire Himalayan mountain range to sea level would not change the moment of inertia of the earth enough to give rise to the observed change in rate of spin. Rather, a world-wide redistribution of the deep inner layers of the earth would be required. It is not hard to believe that such changes could occur, since the earth's crust, in cooling and contracting, must constantly readjust itself. This readjustment is shown by the occurrence of volcanoes and earthquakes; it is even conceivable that accurate measurements of fluctuations in the rate of rotation of the earth could be correlated with observations of very large earthquakes. The observed fluctuations mean that absolute time measurements based on the mean solar day cannot be made with a smaller degree of error than one part in twenty-five million, and similarly all frequencies measured in terms of the mean solar day are likewise limited in absolute accuracy.

One can easily write down the specifications of an ideal new clock to replace the rotating earth. A clock which runs at a constant or invariant rate, is reproducible, and has a time standard determined by the universal constants of nature is desired. (The mean solar day is a completely arbitrary standard, like the meter bar, having no fundamental relation to the structure of the universe.) These specifications immediately rule out all clocks depending on macroscopic entities, such as pendulums and quartz-crystals, because such macroscopic aggregates are always sensitive to external conditions like pressure, temperature and other environmental factors. In addition, no two pendulums or quartz clocks can be made precisely alike, so that if a master or primary standard were destroyed, it would be impossible to reproduce it precisely.

It has long been known that atoms and molecules do have periodic vibrations, or spectrum lines, at sharply defined frequencies, which would make them suitable as time standards; these vibrations are, like all atomic properties, invariant and reproducible. This realization goes back to the beginning of spectroscopy. However, at first it was not possible to utilize this idea because the optical vibrations were at such enormous rates that counting the number of cycles in an unknown period of time was not possible. The discovery of slower vibrations in the microwave range and the development of microwave techniques solved the problem.



The original (left) and a second model of the ammonia clock.

As a result of the need for searchlight-sharp radar beams during the war, the development of the microwave region of the radio spectrum received a tremendous impetus. This is the region which extends from approximately a few hundred megacycles up to the infrared, or in terms of wave lengths, from about a meter down to fractions of a millimeter — very tiny indeed compared to broadcast radio waves which are almost half a mile in length. The remarkable advances in technique led to applications of microwaves in many new directions, among the most important of which was the field of microwave spectroscopy, the study of spectrum lines in the microwave region. It had long been known

that molecules have characteristic, invariant spectrum lines at radio frequencies. It was not until rather recently, however, that techniques were available to make extensive or accurate measurements.

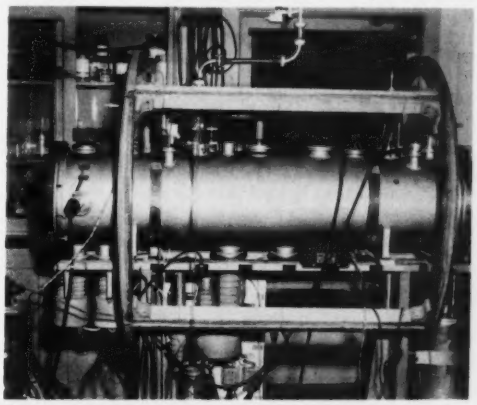
Having an invariant time standard such as an atom or molecule does not mean that, when this time standard is used in a clock, the accuracy and reproducibility of the clock will be equal to that of the time standard. This situation can be explained by considering two clocks, both of which use pendulums as their time standards. The first clock, an ordinary grandfather's clock, keeps time of a fairly accurate sort. The swings of the pendulum are counted up by the gears and hands of the clock. However, a precision, observatory-type pendulum clock does not make the pendulum do the work of driving the counting mechanism. Rather, a master pendulum swings freely in a partial vacuum and controls a slave clock which does all the work of driving the counting mechanism. This enables the master pendulum to run at a very constant rate, giving accuracy far beyond that of the ordinary pendulum clock. Similarly, when the vibrations of atoms or molecules are used as time standards in an atomic clock, it is still necessary to search for the best clock-design methods in order that the over-all clock will be nearly as invariant and reproducible as the atomic vibration itself. This, however, is an ideal goal which can never be precisely obtained in practice. The counting mechanism inevitably reacts back on the system to affect over-all accuracy. In the case of atomic clocks, everything but the atoms or molecules used as time standards must be considered part of the counting mechanism.

The strongest absorption line which has so far been observed in the centimeter wave length range was also historically the first microwave spectrum to be discovered; it was used in the first atomic National Bureau of Standards clock and is a line of the ammonia molecule which occurs at a frequency of 23,870.10 MC. The ammonia molecule is shaped like a pyramid; three hydrogen atoms form the triangular base, while a nitrogen atom is at the apex. The spectrum line used in the clock results from the vibration of the nitrogen atom "up and down" through the base of the pyramid. The frequency was still low enough to enable the counting of the oscillations, yet was high enough to achieve high accuracy — since theory shows that the higher frequencies allow greater accuracy to be obtained. This is partly because the relative sharpness of a spectrum line is greater at higher frequencies; in addition, its intensity is also greater.

Unfortunately, an atom or molecule does not emit or absorb energy at one frequency only, but rather over a range of frequencies. The narrower the range, the more accurate the spectrum line will be as a time standard. The range or width of the spectrum covered by the spectrum line is determined by several factors. Among the most important of these are the violent collisions between the atoms or molecules which disturb the vibration, causing a broadening of the spectrum line. The thermal motion of the gas atoms also gives rise to what is called a Doppler broadening, similar to the change in pitch or frequency of sound heard as a vehicle emitting the sound is moving toward or away from the listener.

If a metal tube is filled with ammonia gas, and radio waves are sent through this tube, the signal will be absorbed at the frequency corresponding to the spectrum line. If the vibrating mechanism giving the beat of the atomic clock is made to generate a radio wave, the absorption of this wave by the gas will be at a maximum when the wave is at the right frequency.

The National Bureau of Standards clock generates the radio wave which is to be absorbed by the ammonia-filled absorption cell by means of an ordinary quartz-crystal, the most accurate type of oscillator available, plus auxiliary circuits. The quartz-crystal is similar to those used in controlling the frequency of broadcast stations, and oscillates at one hundred kilocycles. This frequency is then reduced by electronic frequency dividers until it is low enough to furnish driving current for either a fifty-cycle synchronous motor clock or a special thousand-cycle synchronous motor clock which is designed for exact adjustment and comparison with



This is a new experiment under way using cesium and atomic beam techniques to measure time.

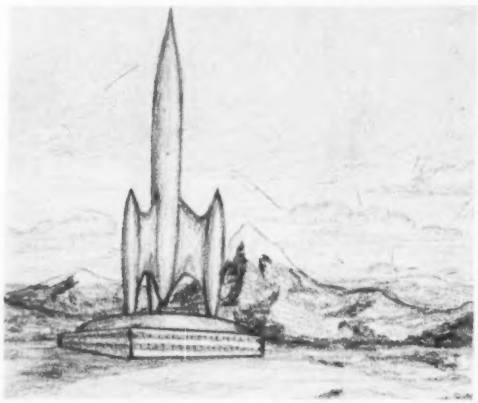
astronomical time to within one five-thousandth of a second. The entire oscillator and divider assembly, called a quartz-crystal clock, is very accurate because of the stable chemical and physical properties of the quartz-crystal. However, it does drift slightly with age, making it necessary to calibrate it in terms of astronomical time units if it is to keep accurate solar time. On the other hand, for periods of several hours to a day, it will run with a constancy of one part in ten billion or better. To make an atomic clock, it is then necessary only to prevent this slow drift by controlling the quartz clock with the spectrum line. This is done by increasing the frequency of the hundred kilocycle signal of the quartz-crystal to that of the vibration of the ammonia molecule, or 23,870.1 ± 0.32 MC. The multiplied frequency is then compared automatically to the spectrum line frequency by sending the generated wave at this frequency through the absorption cell containing ammonia at some ten to fifteen microns pressure. The cell consists of twenty feet of ¼" by ½" rectangular copper tubing wound in a spiral, with two germanium crystals acting as signal generator and detector. If the radio frequency is a little off, the absorption of the signal will not be a maximum and the circuits will generate an error or control signal, which is applied back to the quartz clock, changing its rate to make it agree with the ammonia molecule. The synchronous motor or electric clock counts the oscillations of the system since, through the control circuits, it is effectively geared to the molecules. Recording equipment and a frequency meter are used in checking the accuracy of the clock. For this purpose, the frequency of the clock's crystal oscillator is compared to that of a group of precision, 100-kilocycle quartz-crystal oscillators

(*Continued on page 30*)

upper limit

By Rudolph William Preisendorfer, '52

The control room was quiet. Hidden power sources hummed below the threshold of hearing and filled the air with a tangible heaviness, with the impression of tremendous power just beyond the reach of any of the senses. The control room was dark. Only the panels glowed with a soft, eye-easing blue light. The few dials that covered the board glowed, and registered their impressions on slowly moving needles, and arrays of button-lights winked quietly. Three men were disposed at the various panels in the room. Each was intent upon his own task. A buzzer sounded softly and the man at the control panel looked up from his work into a small screen that lighted into life on the wall before him. The screen cleared, and an image of a face focused



sharply upon the background of a brightly lighted room. The sound from the speaker told of steady sound-emitting power sources in the room shown on the screen.

"Power room to control, Sir."

"What is it, Arrane?" answered the man at the control panel.

"Five minute presurfacing report, Sir. Everything is in readiness. The timers are set, and in synchronism with the control panel. We surface in four minutes and thirty seconds, according to the timers."

"Very good, Arrane. Keep the communication visor on through the operations."

"Yes, Sir." Arrane turned and walked away from the visor pickup in the power room. He headed for the far wall, upon which were placed several panels filled with power instruments.

The other two operators in the control room were now fully aware of their surroundings. The man at the navigation desk raised his eyes to the man at the control panel and said, "In four minutes we will know whether or not we have been spinning our wheels for these past four months, or have been really moving through space at the predicted value of three hundred and seventy-five thousand light-years per year."

Mackley, the man at the control panel, smiled casually, "There will be no doubt about it, we will be one hundred and twenty-five thousand light-years from the Sun when we surface . . . no doubt about that at all. We will be on course, and well below Lorentz-One when we surface, you will see. . . ."

And they saw. The ship emerged into normal-space without a flicker. First there was the vast immensity of a galactic gulf, and then, a tiny, glinting spark — the ship — flashed momentarily in the dull, phantom light of incredibly distant islands of space. The ship had surfaced. The panel lighted into a brighter hue of color, and Nentz, the power room technician, reported, "Everything in order, Sir."

Mackley's eyes raised to the lighted screen, "As it should be, my dear Nentz." No sign of any tension or suspense being dispelled, for there had not been any in his mind.

So that, Mackley thought, was that. What was the difference between an experimental hop in subspace across an Earth-desert, and a quarter of a million light-years of vacuum? What difference should there be? Only a matter of some little time. The time differential function indicated the difference precisely. It was linear. Very kind of nature, indeed. Three hundred and seventy-five thousand light-seconds per second. Kindergarten algebra! Elementary, indeed!

* * *

The ship flashed in the sunlight as it rose majestically into the clear atmosphere. Slowly, and with great leisure, the magnificent needle gained speed, pointing ever upward, going ever faster, leaving no vapor trail and no sound of its smooth passing into the upper atmosphere and out into the upper limit of the Earth's gaseous shell. Its delicately curved path was tracked by surface electronic tracing units for its normal-space trip of three hundred and seventy-two miles up and away. Then, abruptly, it vanished. The electronic tracers clicked into cold sleep, their job done. The first leg of the trip was over, as far as they were concerned.

The designing of the "*Upper Limit*" had been an uneventful chore for a few well-programmed electronic computors. It was a matter of three days, and the tri-prints of the magnificent hull of the *Upper Limit* were ready for the processor engines, which, with deft, quick strokes molded the metal, man-bearing needle into glinting reality. It was with a casual air of assurance that its vitals were stuffed: miles of spider-web wiring installed by quick, sure metallic fingers of the processor engines. Ah, with such fine, smoothly flowing efficiency was the *Upper Limit* shaped into its beautiful form. Three weeks from its inception it stood finished upon its modest platform in the middle of a west African desert, shining like a finely curried steed under the hot, shimmering desert air.

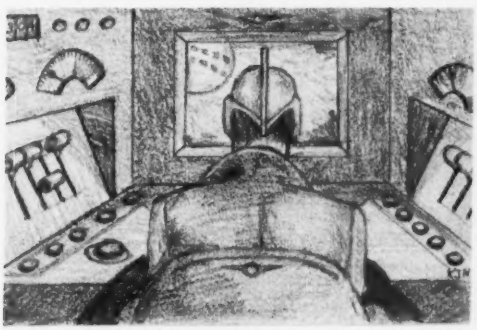
Two scientists of the project stood off from the crowd of technicians servicing the ship. One was tall, with greying hair. He had a one-piece plastic cover-all on . . . the kind usually worn under the standard space-suit. Tiny hose-ends and electrical connections dangled freely from various places of the suit. His arms were folded upon his chest, and he stood looking over his companion's shoulder at the ship. The smaller man was dressed in a laboratory smock, and his hands were

never still; they ran continuously through his thinning hair, and then down along the sides of the smock, as if to dry every little perspiration droplet just as it came out. He was speaking in low, intense tones to the taller man.

"Mackley," the smaller man's voice had a controlled tremble, "how can you stand there and be so complacent?" The taller man flicked his eyes away from the ship. "Ben, we've gone through this scene a thousand times before. I even wasted a whole week for you and your ideas setting up a test run for the *Upper Limit* out to el Giof, and everything worked out as predicted." "You fool," Ben whispered, "you know what my fear centers on. I could have told you of the success of that trifling desert hop. Can't you see, Mac, that the mathematics of this drive is just an idealized model of what really happens? The only thing we are sure of is the time differential that's set up, and hence the velocity of the ship in full drive. What does the drive *really* do, Mac, in order to get such an unnatural velocity out of a material ship?" "Ben, I can't argue any more. If I had the time, I'd stop to convince you of the validity of the drive mathematics once again for the hundredth time. Let me go now, the ship is waiting . . . going to wish me luck, Ben?" "That's all I can do now." Mackley turned, and went toward the ship. Ben stood silently, facing away from the ship, eyes closed, head bowed.

The ship flashed in the sunlight as it rose majestically into the clear desert atmosphere. Minutes later, the ground trackers saw it wink out, and they relaxed their vigil.

Precisely four months later, the ship surfaced into normal-space, easily and smoothly. It emerged into a region of normal-space, dark and very empty. The *Upper Limit* was exactly one hundred and twenty-five thousand light-years from Earth. It was the first of three scheduled surfacings that it would make while



on its way to its destination: a randomly chosen spiral nebula in the direction of the middle button of Orion's belt.

"Prepare to go under!" snapped Mackley.

"Yes, Sir," answered Nentz. "The timers are set, and everything is in order."

Mackley settled back, waiting for the hazy milk-white dish of star clouds in the rear plate to vanish.

Mackley waited. Nothing happened.

The communication visor flashed into life. A confused face was focused upon the brightly lighted background of the humming power room. The characteristic hum was as normal-sounding as ever. Nentz opened his mouth to say something.

"Well, Nentz, what is the reason for this delay?"

"Sir, I . . . the board . . . nothing seems . . ."

"Come now, Nentz, stop this ogling and stuttering, and be more coherent."

"I don't know what to say, Sir. Everything seems to be in or. . ."

"Nonsense, man. Have you checked the synchronism of the timers?"

"Sir, the timers are all set. It's just that she will not go under!"

The *Upper Limit* drifted through nothingness. It drifted through a barren utterly empty stretch of intergalactic immensity. It was, indeed, a long way out from any place. It was alone, drifting at a pitifully slow crawl of point-five Lorentz. One hundred and twenty-five thousand years of space-time from Earth. Five little souls on a chip of metal in the midst of yawning black emptiness. Five little souls being suddenly confronted with the impossible: the mechanical failure of their perfect ship.

A voice whispered in Mackley's mind: "The time has come to speak of many things . . . of Cabbages and Kings . . . and why . . ." "Why?" cried the disturbed Mackley. "Why will we not go under?"

"I don't know, Sir. All the instruments are in perfect working order, and indicate that the submerging unit is intact and in readiness to pull us into subspace.

"Stand back, man!" ordered Mackley, and as his command was obeyed, he enlarged the image of the background panels so that he could inspect them. An entirely normal array of readings greeted his eyes. Well, now . . .

"May I venture an opinion, Sir?" the man at the navigation desk began.

"Well, what is it, Shaeffer?" snapped Mackley . . . his mind was back on Earth with Ben . . . *was Ben right? I am still here, that's proof in my favor.*

"None of the instruments indicate any sort of mechanical fault." The voice of the navigator interrupted his thought, Mackley looked up, and listened. ". . . and seeing that they are self-checking we can be assured that there must be no mechanical or electrical failure. Nor could it be a matter of procedure on our part. I suggest that there is some external cause."

"Nonsense, Shaeffer! Out here? In the middle of nowhere? Impossible! We are the first humans who have ever penetrated this region between the galaxies."

"You are overlooking one obvious possibility, Sir." The third man in the control room spoke for the first time since the surfacing.

"And," asked Mackley, "what could that be?"

"Non-human intervention," answered the man.

"Possible, but unlikely, Sweter. First of all, there is no sign of solid, or gaseous, or any other form of matter within a hundred thousand light-years of us, if I can believe those instruments before me."

"Apparently you cannot, Sir," answered Sweter. "They certainly aren't telling us the truth about the internal situation that prevails; why should they record correctly the external surroundings?"

The proximity-buzzer roared into life. Something was near the outside of the ship.

"Another ship, Sir!"

"Confound it, man, I am aware that it is another ship! Why haven't we picked it up on our screens before this? Take a reading Sweter, and report as soon as you finish."

"Arrane, how is the situation in the engine room?"

"The same, Sir. Everything is in working order, but it just would not work . . . frankly, Sir, I'm puzzled."

"You needn't be any longer. We are quite certain

(*Continued on page 36*)

tech engineering news

Professional Journal of the Undergraduates of the
Massachusetts Institute of Technology

Managing Board

Charles M. Saltsman, '52	General Manager
Sherwin Kalt, '53	Editor-in-Chief
Anthony Ranti, '53	Managing Editor
Bernard Gordon, '52	Business Manager

Junior Board

John Mathis, '53	Literary Associate
Herbert Jacobson, '54	Make-Up Editor
George Wodopjanow, '54	Art Editor
Will Thompson II, '53	Advertising Manager
Hans Akselsen, '54	Office Manager
Nereo Agostinelli, '54 Charles Homsy, '53	Co-Sales Managers
John R. Schrieffer, '53	Circulation Manager

Staff

Dan Brzezenski, '53
Ray D'Arcy, Jr., '54
Donald Eckhardt, '55
Norman R. Gardner, '53
Dave Klepper, '53
Jan Piotr Kowalski, '52
Bert Krauss, '54
Knute Nomland, '55
Vic Seeger, '54
D. F. Shrader, '57
Howard Simmons, '54
Philip Sperling, '52
Kevin Woelflein, '54

Publisher's Representative

Littell Murray Barnhill, Inc.
101 Park Avenue, New York
605 North Michigan Avenue, Chicago

from the editor's notebook

Revise Our Calendar? . . .

Our school schedule has been followed for some time now with only minor revisions. We have become so accustomed to returning to school in the middle of September, a short Christmas vacation, and final exams in January, that it rarely occurs to us that there might be better ways of doing things. Is this schedule so perfect? I believe not.

Let us consider the schedule as it looked this year. We attended school from the third week in September through the third week in December, were then given two weeks off, attended classes for two weeks in January, and spent one week on final examinations. This amounts to a total of seventeen weeks in school for the first term. We were then given one week vacation between semesters. The second term started the first week in February and will continue through the last week in May, with one week vacation in March. This is a total of sixteen weeks, including finals.

The months of December and January provide three weeks of vacation. These, however, are broken up by finals, making the Christmas recess a "heads I win, tails you lose" proposition to many. Some students will spend this time studying for final exams, thus losing the benefits of a two-week vacation. Many will do little or no studying and will return at a disadvantage when school starts. In any event, this vacation is clouded by thoughts of what is to come. It would be a great improvement to take final exams before vacation, and to combine the Christmas and Midterm vacations into one long recess. This would be much fairer to the many students here who live far away from Massachusetts and who now have to waste a third or more of their vacation traveling there and back.

How can this be done? Here's how. If school were started the first week of September there would be two weeks gained. The Fall Term, sixteen weeks long, could end (including finals) before the Christmas vacation. The two weeks of Christmas and the one week at Midterm could be combined to give three weeks without school. Remember, further, that the two weeks gained by starting school early have not been used as yet. One of these weeks could be added to the Christmas vacation, making it a full month long. The other week could be used in one of many ways: The Spring Term (seventeen weeks long) could be ended one week earlier. A study week could be added before finals, or the Easter vacation could be lengthened one week.

In other words, the revised school calendar would look something like this: Fall Term starts the first week in September and ends the third week of December; four weeks Midterm vacation; Spring Term starts the third week in January and ends the third week of May.

It sounds good to me. What do you think?

S. K.

In This Issue . . .

"Cyclic Analysis" by **Stan Amstutz** handles a topic which is gaining increasing recognition, the prediction of natural phenomena and business happenings by a study of their cyclic recurrences. This article should be of interest to all wide-awake citizens.

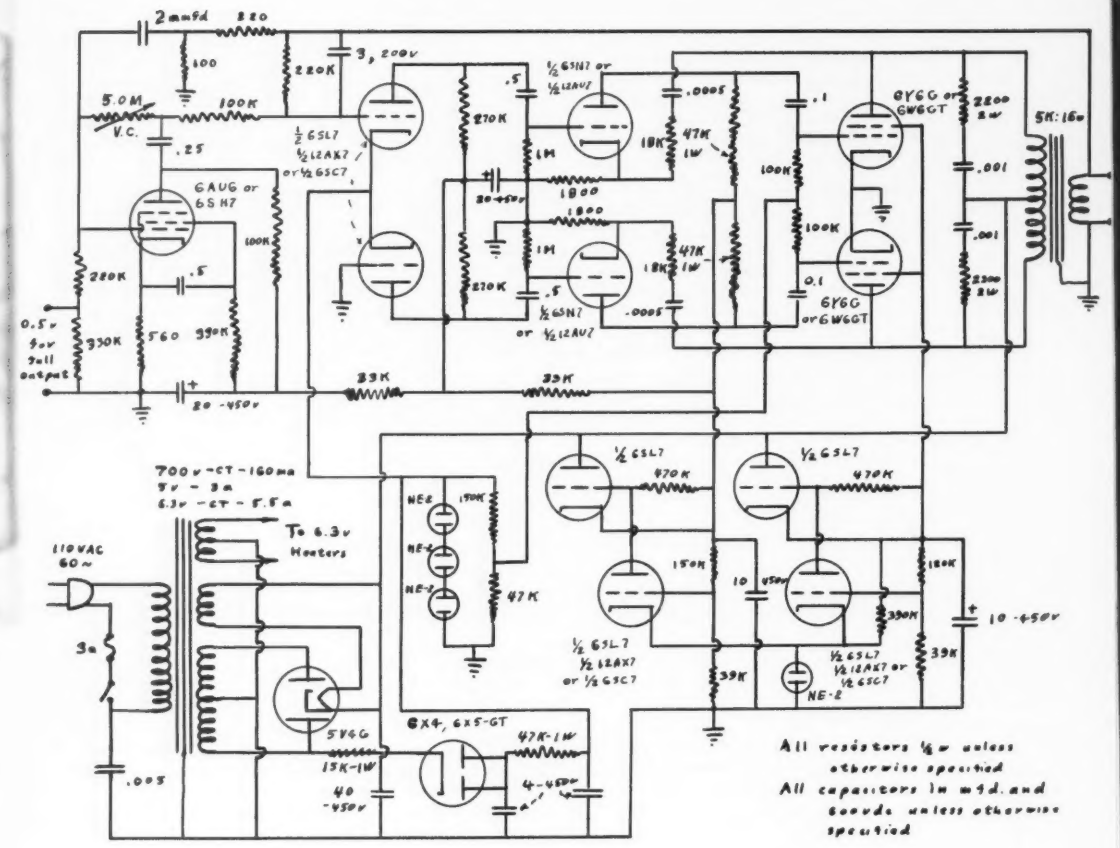
Harry Davis is a graduate student majoring in math. You may remember his previous articles on "Chess and Mathematics" and "The Fourth Dimension."

Norman Gardner is a Junior in Course III, Metallurgy. This is his second contribution this term on topics related to the subject.

Dave Klepper has finally been lured away from his favorite subject, transits, to write an article about the R.O.T.C. His article is intended to aid the student who has already decided to enter the Advanced Course, but is not certain which branch is best for him.

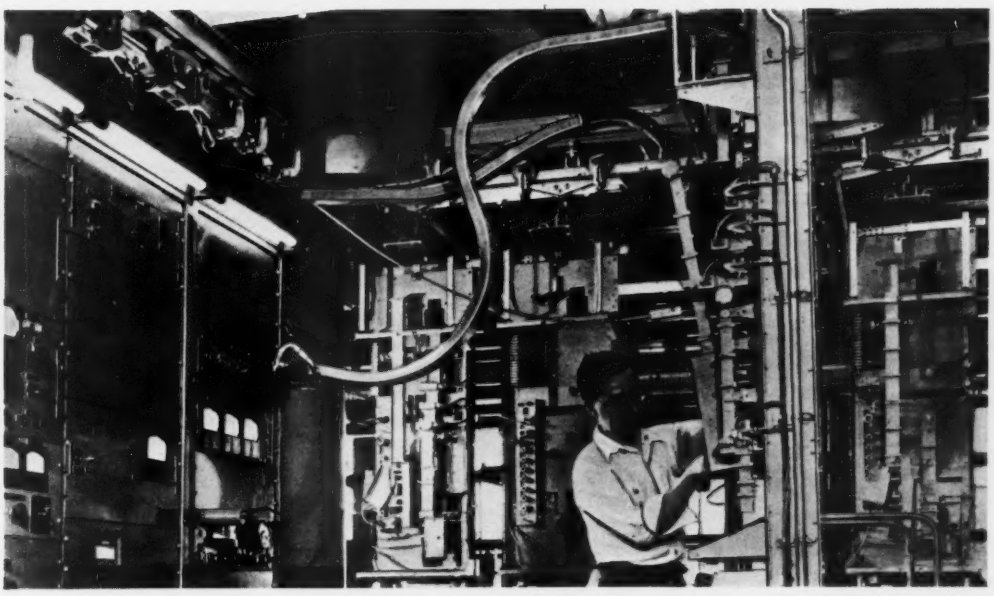
noble-young amplifier diagram

Herewith is published the schematic of the Noble-Young amplifier originally discussed in the December 1951 issue of *T. E. N.* A major circuit revision has made it possible to reduce the number of tubes shown here, and to include a preamplifier for magnetic cartridges. This newer design has the same response and distortion figures as the older schematic shown here, but the newer amplifier puts out much more power, some fifty watts. It uses push-pull 6L6's, and has a very high signal to noise ratio. It will be on sale, it is said by Tim Noble, one of the inventors, within three weeks at Lafayette, and at that time full schematics will be available. Unfortunately, at the present time the new schematic cannot be released, and the old one is published as a guide. There is only one critical section of the amplifier, an equalizer section. However, it will be made available, wired and potted, at the time the amplifier is released, at a very nominal cost, for those who desire to build this amplifier at home. Also, the circuit included with this article, as well as the regular amplifier, uses a particular output transformer, not specified here. It is important to note that if any other output transformer is used, the amplifier will oscillate incurably. Therefore it would be very wise to wait awhile and find out which output transformer the inventors have in mind, rather than resort to experimentation with costly output transformers.



Drawn by Jack Dennis, '53

Where engineering and pioneering go together!



The transmitter-receiver bay unit being worked on by a Western Electric tester, is part of the complex equipment installed in the Bell System's coast-to-coast microwave relay towers. Special testing equipment is at the left.

Operator inspects a grid blank. The grid controls the flow of power through the tiny electron tube which is the heart of radio relay. Western Electric engineers designed machines to wind wire .0003 inch in diameter on the grid at 1000 turns per inch—spaced exactly .0007 inch apart.

COMPLETION last Fall of the Bell Telephone System's coast-to-coast radio relay route climaxed a production feat that involved doing many things never done before.

The engineers at Western Electric—manufacturing unit of the Bell System—were treading on uncharted ground when they tackled the challenging job of making the highly complex equipment.

This radio relay equipment—which transmits telephone and television signals at a carrier frequency of four thousand megacycles per second—called for many components never made before and for which no machinery, no tools, no assembly processes were known. Some components required almost unbelievably tiny parts—and fantastically small tolerances.

Manufacturing facilities and techniques had to be developed to assemble and wire the complicated equipment which receives signals having less than 1/10 millionth of the power of an ordinary flashlight bulb—at frequencies ten times as high as those used in television sets—amplifies these signals 10 millionfold and transmits them to the next tower some 30 miles away.

Finally, Western's engineers were responsible for installing the equipment in 107 towers across the nation.

In all phases of this job, engineers of varied skills worked closely together as a team which just wouldn't be stopped merely because "it hadn't been done before." That's typical of work at Western Electric—where engineering and pioneering go together.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

cyclic analysis

(*Continued from page 6*)

The technique by which economic predictions are made is an extension of this analysis. Once the major constituents of any economic curve, such as the above, have been determined, they can be recombined, or resynthesized. This serves as a check upon the correctness of the analysis. But, more than this, once the basic constituents are found, we need not stop with the synthesizing process at the point where data ends, but can project the curve into the future! Thus the possibility for prediction appears. First by analysis and then by resynthesis, theoretically the most complex economic curve can be projected into the future and used as a tool for prediction. If this technique is valid, it can obviously be applied to a graph of the national income, the sales of a specific industry or business, et cetera.

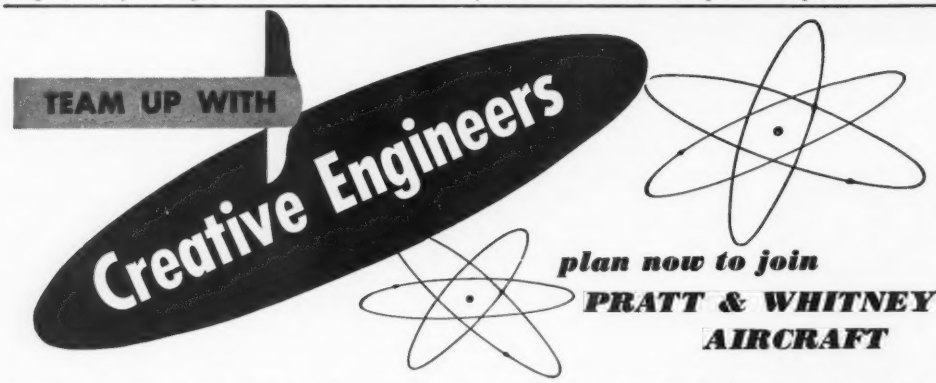
There appear to be four basic rhythms, which, with others, form the constituents of all economic cycles. These four manifest themselves particularly in certain areas. A rhythm with a period of fifty-four years is that by which wholesale market prices appear to fluctuate. That is, we have experienced especially high prices here in the United States around 1820, 1864, and 1918. Obviously these peaks in wholesale prices came during the three great wars of this nation prior to the present day. For that reason, it might be well to consider the influence of wars upon variations in economic activity.

The logical conclusion is: wars, and not an arbitrary rhythm which some eager would-be discoverer of cycles has read into the statistics, determine the high points in economic activity. Certain economists meet this argument by calling attention to the fact that, by analysis and resynthesis of various cycles, students of cycles predicted especially high prices during 1942–1946 even before the actual threat of war appeared. Their treatment of wars is: only the amplitude of economic fluctuations during wars cannot be foretold, but the timing of wars can be predicted, or at any rate especially high prices will be indicated during the period when the war subsequently occurs.

Briefly, the other three basic economic rhythms which have been discovered are: the nine-year rhythm which apparently describes the behavior of common stock prices, the three-and-one-half-year rhythm in industrial production of the United States, and the eighteen-and-one-third-year rhythm which has special use in the description of real estate activity, the amount of building being done, and the number of marriages per year.

What can be done with cycles? Can they really be considered reliable as a means of prediction? The answer to these two questions is, in my opinion, yet to be seen. Relatively little is known about cycles. However, they certainly should not be ignored as a scientific method. Merely because we do not understand how they operate, or why certain phenomena repeat themselves at regular intervals, we have no reason to deny ourselves the use of the results as long as past experience shows that probability of being right is in our favor. When more is learned of cycles, and when we gain confidence in our methods, we may begin to use this method as a means of economic prediction. When this time comes, cyclic analysis can gain the status of a true science.

An interesting closing thought over which you may like to ponder the coming year is: since all four major economic cycles are to reach a low point simultaneously in 1952, a colossal depression is predicted.



FOR over a quarter of a century the Pratt & Whitney Aircraft Division of United Aircraft Corporation has depended upon *creative engineering* to bring its products to the forefront.

How well this idea has worked is amply demonstrated by the outstanding leadership record which Pratt & Whitney has established in both piston and turbine aircraft engine types.

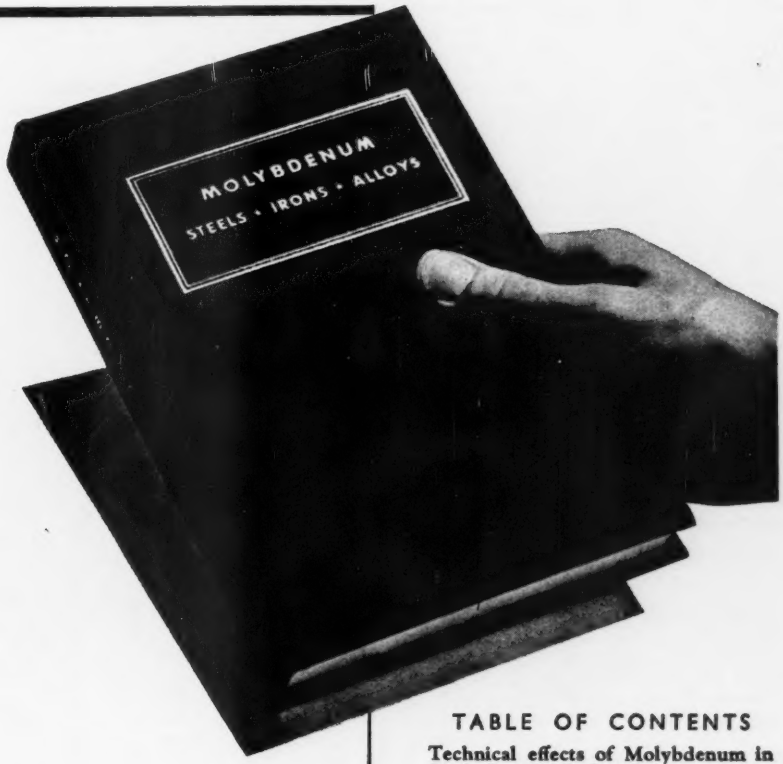
And for the future, because of its sound engineering background and research facilities, Pratt & Whitney is one of the few companies in the country to be selected to develop an atomic powered engine for aircraft.

Creative engineering will continue to be given top emphasis at Pratt & Whitney—and it might well be the best answer to *your* future too—if you want a chance to put *your own* ideas to work.

Why not find out where you could fit into this great engineering organization? Consult your Placement Counselor or write to Frank W. Powers, Engineering Department at

PRATT & WHITNEY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION
EAST HARTFORD, CONNECTICUT

For metallurgist and engineer . . .



This 400pp. book describes the varied applications of Molybdenum as an alloying element in a wide range of materials. It presents the fundamentals which must guide the selection of the most suitable alloys for specific applications.

Much recent information is included, some of it hard to find elsewhere. About 500 references to technical literature facilitate further reading, and there are 187 diagrams and 91 tables.

The book is available free on request by metallurgical and engineering students.

Climax Molybdenum Company
500 Fifth Avenue New York City

C16

TABLE OF CONTENTS

Technical effects of Molybdenum in Steel, Cast Steel, Cast Iron.
Fundamental Effects of Heat Treatment on Microstructure.
Addition of Molybdenum.
Wrought Alloy Engineering Steels—Medium, Low, High Carbons; Low Temperature Properties, Machinability.
Wrought Corrosion Resistant Steels.
Wrought Steels for Elevated Temperature Service.
Tool Steels. Steel Castings. Cast Iron.
Special Purpose and Nonferrous Alloys.

Please send me "Molybdenum: Steels, Irons, Alloys".

NAME .....

STATUS ..... MOLY

ADDRESS .....

.....

.....

MIT-2

scientific method

(*Continued from page 7*)

Why are groups so important? One reason is that all of geometry can be unified by using the group point of view. The study of geometry is essentially the study of those properties of geometrical figures that remain unchanged under certain geometric transformations. In Euclidean geometry, we are interested in such notions as length and angles, which are properties that remain unchanged under translations and rotations in the plane. The group that contains the translations and rotations is therefore called the Euclidean group. In affine geometry, the basic group is the affine group, in which the plane can be shrunk or stretched. This corresponds to the fact that, in affine geometry, any two triangles are equivalent, in contrast to Euclidean geometry, where congruence of triangles is a special case.

In the theory of relativity, proceeding from the observation that the velocity of light is always the same, no matter how the observer moves relative to the light source, we build up a geometry in which the transformations of the group preserve this constant. The resulting geometry of space-time considers laws of nature significant only if they are invariant to this group of transformations, called the Lorentz group.

In crystallography, crystals are classified by their "symmetries." Whenever we speak of symmetry we are using the group concept. We say that the crystal remains unchanged in appearance when it is transformed in a certain way (perhaps a rotation), and these transformations are the elements of a group.

The idea of symmetry helps us in solving certain problems in physics, even though we may not realize it. If, for example, we are calculating the electric field potential about a charged sphere, we have "spherical symmetry," and it is therefore reasonable that this potential should be a function of r, the distance from the center of the sphere, but not a function of any of the angles. In group theory we would say that the function is invariant under all rotations, and the only functions that possess this property are functions of r alone.

All this still does not sufficiently emphasize the fundamental significance of groups. As Wiener and others have repeatedly emphasized, the essence of a useful law of physics is that it represents a property of the system under discussion that remains the same under changing circumstances. That is, it is an invariant of a certain group of transformations. The "law of consistency of natural phenomena" states that experiments repeated give the same results. This means merely that if the experiment, which is an event in space-time, is translated in space-time, it is essentially unchanged. That is, the result of the experiment is invariant. It should be remarked that this must be given a probabilistic interpretation in some cases, but the central idea of invariance is still there.

The study of invariants in general occupied most of the time of nineteenth century mathematicians, and led for example to the tensor calculus, which is the mathematical system in which relativity is formulated. It is interesting to note that the definition of "fibre bundle," a mathematical object of recent interest, is a group, and it is just this group aspect of the fibre bundle that permits "twisting in the large." What this means in ordinary English is that, if we take a long strip of paper and glue its ends together, we get a cylinder. If, however, we twist the strip before glueing its ends together, we get the famous one-sided Moebius Strip, which has the peculiar property that if it is cut lengthwise you still have only one ring, not the expected two. Magicians find this concept useful in entertaining children, for if the strip is several yards wide the twist is not noticeable, and the strip looks like any other. Its mathematical interest arises in its "nonorientability." In order to describe the object neatly in modern topology, the notion of group is introduced, the group element being the "twist" in the loop.

Structure

We have ample evidence for concluding, therefore, that what we call the structure of a science is closely tied up with the idea of a group invariant. This point of view, though broadening, is not always helpful practically. This is because the structure of groups is a very difficult problem. What, indeed, do we mean by the structure of a group? We mean, how can it be divided into simpler objects, what are its invariants, how can I represent the group, and a variety of other things. In some sense, we mean, "how can the group be visualized?"

We now arrive at a delicate point in the discussion. It is the problem of visualization. When the mathematician uses a mathematical object, whether it be a group or a fibre bundle, he is visualizing something. At some time in his training, he has acquired a mental picture of the object that satisfies him to a greater or lesser extent. At any rate, he is certainly not content with a definition alone, unless the object is truly a trivial one.

Just what do we mean by the visualization of an abstract concept? We visualize apples and chairs by their physical properties. We have seen a chair, we have eaten an apple. How, then, do we visualize a physical object such as a magnetic field, or the mathematical concept of group? The physicist has used the concept of magnetic field so often in solving problems that he really has a feeling for the concept. He doesn't merely know that the force on a charge moving in a magnetic field is obtained thus-and-so. He doesn't think of a formula or a particular diagram. He has become familiar with the properties of a magnetic field, through *experience* with magnetic fields, in the fullest possible sense of the word.

It is not unfamiliar for a physicist or a mathematician, in discussing a very familiar subject among themselves, to be asked by others, "Do you really know what you are talking about?" What is very vague to a novice (as the group concept must surely be to the reader, if his only knowledge is derived from this article!), is very specific and meaningful to the person who has experienced the concept. It is the mark of a great teacher to get this experience across to his students in the classroom. Since most of us are not great teachers, we give our students many problems to work, in the hope that, by experiencing the concept (i.e. by using it repeatedly), the student will acquire the visual picture that we possess. It is the mark of the inexperienced teacher to suppose that an abstract definition, or the description of a procedure not demonstrated, will be understood thereafter. It is only when an enthusiastic teacher can make a student actually think that he is himself working the problem at the board, that much is accomplished in the classroom.

It may be objected that the word visualization is being misused here. But no, more than any other sense, the visual sense is the one used in experiencing abstract ideas, even though the idea is not one that has physical form. I have never met a group walking down the street, but somehow I visualize it.

The lesson is simple, then. Effective teaching is

(*Continued on page 26*)

Into your home, through the miracle of television, comes a new world of entertainment, news, education, and sports.

They can still go out while staying home

Now "homebodies" who seldom leave their neighborhoods can view programs from distant cities—with all the comforts of home. Drama, comedy and variety shows are brought into the living room. Sports, news events as they happen can be viewed by all. Now television is open coast to coast . . . Those in the East may look in on the West, and the West may look in on the East.

Television is enjoyed in more than 15 million homes, as a result of research at the David Sarnoff Research Center of RCA at Princeton, N. J. Today's image orthicon TV camera was perfected there. Dr. Vladimir K. Zworykin of RCA developed the *kinescope*—which is the screen of television receivers. And RCA scientists have also perfected electron tubes, circuits, sound systems, phosphors, and antennas to make television part of everyday life.

The development of modern all-electronic television is only one example of RCA research at work. This leadership assures you high quality performance from any product or service of RCA and RCA Victor.

• • •

See the latest wonders of radio, television, and electronics at RCA Exhibition Hall, 36 West 49th St., New York. Admission is free. Radio Corporation of America, Radio City, New York 20, New York.

CONTINUE YOUR EDUCATION WITH PAY—AT RCA

Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

- Development and design of radio receivers (including broadcast, short-wave and FM circuits, television, and phonograph combinations).
- Advanced development and design of AM and FM broadcast transmitters, R-F induction heating, mobile communications equipment, relay systems.
- Design of component parts such as coils, loudspeakers, capacitors.
- Development and design of new recording and producing methods.
- Design of receiving, power, cathode ray, gas and photo tubes.

Write today to College Relations Division, RCA Victor, Camden, New Jersey. **Also many opportunities for Mechanical and Chemical Engineers and Physicists.**

RADIO CORPORATION of AMERICA

World Leader in Radio—First in Television

Only STEEL can do so many jobs

THE SINEWS OF DEFENSE are mostly steel, whether weapons, or steel mats, or the steel strapping that binds boxes of supplies. And for years, United States Steel has followed an uninterrupted program of expansion . . . so that it can produce ever-greater quantities of steel to help safeguard America's security.

NEW DELAWARE MEMORIAL BRIDGE, linking southern New Je sey and Delaware, will have an estimated traffic of 5 milli vehicles a year. The bridge proper, with a total length 10,765½ feet, contains the world's sixth largest suspensi span, with a center span of 2150 feet. U.S. Steel produc used include the structural steel, U·S·S AMERICAN Hi Tensile Wire for the huge cables, U·S·S TIGER BRA Wire Rope and Universal Atlas Cement. The giant stru ture was fabricated and erected by United States Ste

FACTS YOU SHOULD KNOW ABOUT STEEL

In the United States, there are 253 steel companies; 375 iron and ste plants. The payroll of the iron and steel industry in 1950 amounted $2,390,000,000, and its approximate total investment to $6,750,000,00 The industry employs 635,000 people, exclusive of non-steel jobs, an has 650,000 stockholders.

so well

FLOODWALL OF STEEL. 76 earth-filled cells like this, built of interlocking U·S·S Steel Sheet Piling, protect a Kentucky rolling mill against flood waters in the Ohio River Basin. Because of its great strength, long life, and low installation cost, this product of U S. Steel is invaluable in all types of projects involving control of earth and water.

EASY WAY UP FOR A FAST TRIP DOWN. Skiers at Sun Valley find this "chairway" designed and built by U.S. Steel, a big help in mounting the world famous ski slopes of this popular Idaho resort. U.S. Steel's Tramway Division can design and build you anything from passenger tramways to freight tramways for transporting sand, gravel, coal, lumber, ore, limestone and many other materials.

STORY-BOOK DRAGON? No, this is a continuous miner, built to be highly maneuverable in a cramped, underground coal mine. With cutting bits mounted on electrically powered chains . . . it rips the coal from the seam face . . . and then conveys it automatically into transportation equipment for removal above ground. One of the wonders of modern invention, this powerful machine is made of tough, enduring steel. Only steel can do so many jobs so well.

MANUFACTURED FROM USS STEEL UNITED STATES STEEL

This trade-mark is your guide to quality steel

Listen to . . . The Theatre Guild on the Air, presented every Sunday evening by United States Steel. National Broadcasting Company, coast-to-coast network. Consult your newspaper for time and station.

UNITED STATES STEEL *Helping to Build a Better America*

ERICAN BRIDGE . . AMERICAN STEEL & WIRE *and* CYCLONE FENCE . . COLUMBIA-GENEVA STEEL . . CONSOLIDATED WESTERN STEEL . . GERRARD STEEL STRAPPING . . NATIONAL TUBE . . WELL SUPPLY . . TENNESSEE COAL & IRON . . UNITED STATES STEEL PRODUCTS . . UNITED STATES STEEL SUPPLY . . *Divisions of* UNITED STATES STEEL COMPANY, PITTSBURGH

GUNNISON HOMES, INC. · UNION SUPPLY COMPANY · UNITED STATES STEEL EXPORT COMPANY · UNIVERSAL ATLAS CEMENT COMPANY

Fruit Storage Stops Shrinkage with New Frick Refrigerating System

Gillan Brothers maintain relative humidities of 85 per cent or higher in their 40,000-bushel apple storage at St. Thomas, Penna., even with temperatures of 32-33 deg. F.! These humidities keep the moisture where it is wanted—in the fruit.

This remarkable cooling system is equally desirable for storing vegetables, nuts, hides, textiles, and other products. Covered by patent applications, the new Frick system is revolutionizing cold storage practice.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, offers a career in a growing industry.

Two Frick Ammonia Compressors Used for Cooling Gillan Brothers' Apple Storage.

DEPENDABLE REFRIGERATION SINCE 1882

FRICK CO.

WAYNESBORO, PENNA. U.S.A.

Also Builders of Power Farming and Sawmill Machinery

scientific method

(*Continued from page 22*)

pictorial teaching. Too often a lecturer uses a mental picture of his own, but does not communicate any part of it to his students. Such an idea as integration can be defined rigorously several ways, but if it is made to appear a natural concept, a more general addition, then something is accomplished. Unfortunately, addition to a freshman is a grocery-store concept, for he does not know that continuously changing variables have a cumulative effect that add up in some way; he is not familiar with the examples that ultimately show the usefulness of the integration concept.

If these pedagogical remarks appear beside the point, then let me emphasize the question. Can we define structure? Not precisely. The structure of a subject is largely a cultural notion; it exists in the culture of the people who work in the field. Education in the subject consists, as eloquently expressed by Sir Richard Livingstone, of learning to know what is first-rate. As we all know so well, a student learns this from personal contact with people who are first-rate, and not from the diagrams and equations to which he is exposed. After he has learned what is first-rate in a field of study, he has less trouble doing the same in other fields. Why? It is in part due to the fact that the methodology is the same. It is precisely this methodology that comprises cross-structure.

Superstructure

The idea of superstructure is sufficiently familiar to the freshman. The structure is the group of real numbers, that he is taught to visualize as the X-axis. The superstructure is exemplified by the function on the real numbers, i.e., the graph. In calculus the notions of slope and area are studied, but the basic idea is still the relationships between numbers. Ultimately, the measurements that are made in technical work are expressed by means of numbers. Yet we have built up an elaborate study of functions, including differential and integral calculus, to study the relationships that can exist. In doing so we have passed from the static to the dynamic, we study things that change by means of things that do not change. That the word "variable" is commonly used but is currently in disrepute among mathematicians, points out the increasing breach between the abstract point of view and the applications of abstract theory.

A graphic example of the superstructure occurs in the study of groups by means of their "group algebras." I do not care to define the term here, but the group algebra is essentially a superstructure that is built up out of the elements of the group. In order to study the group, we establish relationships between the group and its algebra, and then carry the knowledge gained in studying the algebra back to the group. The advantage of this is that the algebra is more tractible to investigation than the group. Similarly, the reader who is familiar with von Neumann's "Rings of Operators" will recognize an instance of the same idea: It is easier to study rings built up out of operators than operators themselves. To define the technical terms would take us too far afield.

The idea of mathematical representation is now basic in all physical science, and is related to the idea of superstructure. With a physical system we make correspond some mathematical gadget that has properties sufficiently complicated yet sufficiently simple. Some complexity is necessary in order that the mathematical object represent the physical system with sufficient flexibility, but it must be simple enough to yield to methods within the bounds of existing mathematical knowledge. This limitation should be clearly realized. The physicist has not the slightest whit of trouble writing down differential equations that closely represent the behavior of a physical system, and that no one is able to solve.

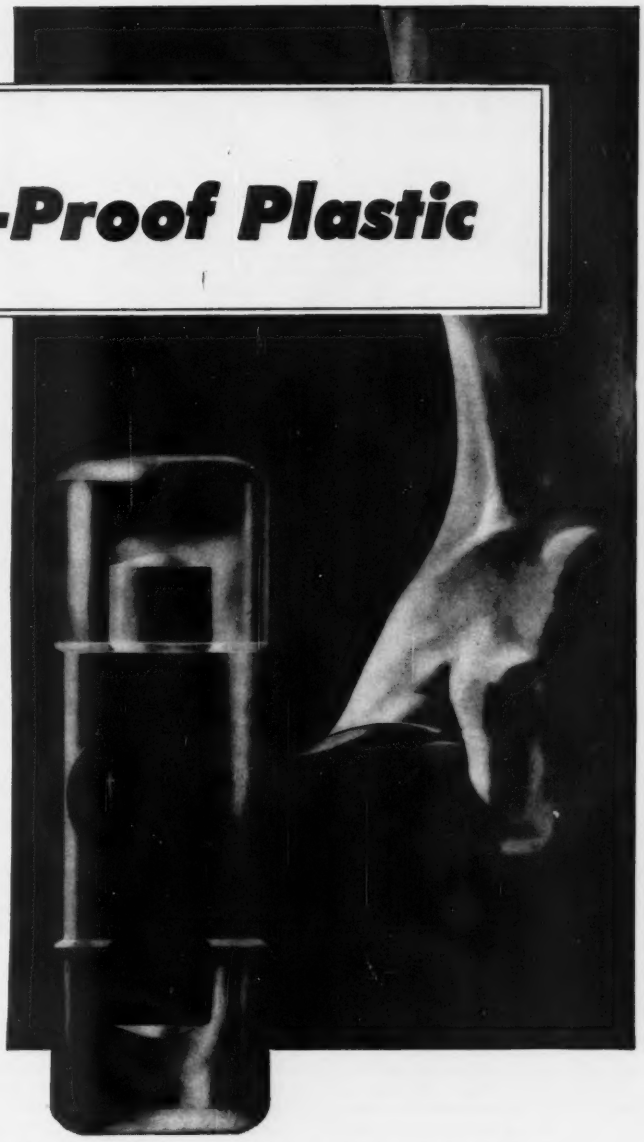
We feel obliged to mention the dual objects that arise in cross structure, but the mathematical examples of interest are impossible to describe briefly. An engineering example is more appropriate, but may not be familiar to one who is not an electrical engineer. We can replace an electric circuit, consisting of certain resistors and voltage sources, by a dual circuit, in which voltage sources are replaced by current sources, resistors in parallel are now in series, and so on. Duality also comes up in physics, both in relativity and in quantum mechanics. In some sense, energy is the dual of time, and momentum is the dual of position.

Cross structure

Cross structure is the study of relationships between objects and their duals, between physical systems and their representations, between structures and their superstructures. It is the study of relationships existing between the various levels of experience. It was once thought that ideas of large and small are purely relative. Quantum mechanics seems to have changed this, so we can actually speak in absolute terms about size. The physicist is aware of three orders of size, three structure strata. One of these is on the atomic level, the other is the ordinary level of experience, and the third is the astronomical level. It is interesting to trace the familiar $F = ma$ through these levels. It can be derived

(*Continued on page 28*)

Pound-Proof Plastic



CHEMICAL PROBLEM...

. . . to provide a tough material for the heads of "soft-face" hammers used to form sheet metal in such work as the fabrication of airplane sections.

SOLUTION...

. . . Hercules® Ethyl Cellulose . . . an extremely tough and durable plastic widely used for tool parts and other industrial needs. No other low-cost plastic can match its impact strength and resistance to distortion from humidity and temperature extremes. "Ethyl" now plays a major role in many key defense and civilian products.

COLLEGE MEN...

This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

Hercules' business is solving problems by chemistry for industry...

. . . textile, paper, rubber, insecticides, adhesives, soaps, detergents, plastics, paint, varnish, lacquer, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.

HERCULES

HERCULES POWDER COMPANY Wilmington, Delaware
Sales Offices in Principal Cities

WHERE
TENSION CONTROL
AND LEATHER
make a good team
FLAT LEATHER BELT
TENSION CONTROLLING MOTOR BASE
In the fielder's glove, a hand controls the tension that makes the leather take hold. In the Uni-Pull drive, a tension-controlling motor base and a modern leather belt team up in practically the same way. The base maintains belt tension . . . keeping leather's high pulley grip at work, effectively transmitting power.
American LEATHER BELTING Association
Headquarters for Authentic Power Transmission Data
41 PARK ROW, NEW YORK 38, NEW YORK

If the original set A consists of the three elements a,b,c, then B is the set (a), (b), (c), (ab), (ac), (bc), (abc). B has more elements than A.

In general, even if A has an infinite number of elements, B has more elements than A. The reader might object that one infinity is just as infinite as another, but this is not the case. The distinction between infinities is important. For example, consider the sequences

$$1,2,3,4,\ldots$$
$$2,4,6,8,\ldots$$

These two sequences both have an infinite number of elements. The infinities are the same, for the two sequences are set side by side, there being a one-to-one correspondence between the elements of the sequences.

However, consider the set of all real numbers, including the irrational numbers like $\sqrt{2}$. This set has an infinity of elements, but it can be proven that this is a larger infinity. It cannot be put in one-to-one correspondence with sequences of any kind.

One of the great unsolved problems of mathematics is whether there exists any collection of objects having infinitely many elements, which has definitely more elements (in this new sense of the word) than an infinite sequence has, but fewer elements than there are real numbers. We observe that the problem arises in considering relations between levels, where we define levels from the viewpoint of the infinities.

We mentioned earlier that ideas applying to one level cannot be applied indiscriminately to another. This was clear in the example chosen from physics, but must be considerably qualified in discussing mathematical logic. A typical example of what occurs is the case of the barber who shaves those people, and only those people, who do not shave themselves. Here we are mixing up, in the same statement, two levels, the people themselves, and the subsets of people (those that do, and do not, shave themselves). We ask the question: Does the barber shave himself? If he does shave himself, he is in the class of people who shave themselves, hence he does not shave himself. If he does not shave himself, then he clearly shaves himself. Contradiction arises either way.

A kind of strata structure that does not relate to the logical categories, is that arising from different operations on the same mathematical object. For example, the concept of a prime number deals with multiplication. A number is said to be prime if it has no divisors except itself and 1. A number such as 8 is not prime, for $2 \times 4 = 8$. It has been observed that every even number is the sum of two primes. For example, $8 = 5 + 3$, and $20 = 17 + 3$. The physicist would consider the statement to be true, for experimental induction says so: Every even number tested so far is the sum of two prime numbers. Despite many attempts, the assertion has never been proven. The difficulty arises because the concept of prime number is one dealing with the multiplication aspect of numbers, whereas

(*Continued on page 32*)

scientific method

(*Continued from page 26*)

from the postulates of quantum mechanics, but has meaning only when we have a large number of particles. It ceases to be valid in calculating the advance of the perihelion of the planet Mercury, where relativistic effects become appreciable.

The main problems arising in modern physics are due to the existence of this strata structure. An experiment must be man-sized, but it must be designed to study phenomena that are of another order of magnitude. Now, as we shall see, the main problems arising in modern mathematics are likewise due to strata structure. The days of mathematical models are mostly over; we spend little time looking at plaster of paris models, for our objects cannot be represented this way. Just as the physicist must design apparatus to confront one level of experience with another, much of the mathematician's concern is with relating abstract objects with things that can be calculated. The number theorist may be interested in the distribution of prime numbers for very large numbers, but on paper he studies the zeta function.

The various layers of structure form a hierarchy, of which the simplest example is the following. Let us consider a collection of objects, A. The objects might be numbers. Now we can consider certain subsets of these numbers. Let us denote by B the set of all subsets of A. That is, the elements of this new set B are collections of elements of A. This is, in turn, a perfectly respectable set, so we can consider the set of subsets of B, and call this set C. In turn, set D would be the set of all subsets of C, and so on ad infinitum.

What's Happening at CRUCIBLE

about special shape type steel

5. The flash trimmed off after the swadging operation.

6. The finished type ready for hardening, plating and soldering to the type bar.

The production of Crucible steel for this job is the result of engineering and practical know-how combined with a special method of manufacture to assure a homogeneous microstructure for maximum forming properties, excellent surface characteristics for good die life, and close accuracy control for all dimensions of the shape.

The production of type steel requires the use of small precision rolling mills equipped with shaped rolls and operated by skilled workmen. During preliminary and final inspection, shadowgraph equipment is constantly used to check for size accuracy.

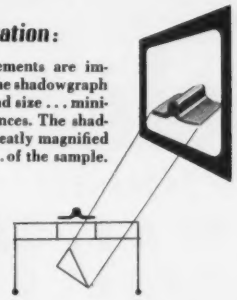
As a result of its outstanding quality, Crucible's special shape type steel is constantly in demand and used by leading typewriter manufacturers.

Crucible special purpose steel for type character application

The development of cold rolled special shape type steel is one of Crucible's important contributions to the business machine industry. A major part of the type characters used for the manufacture of typewriters are made from this special shape.

Shadowgraph Operation:

Since micrometer measurements are impractical due to the shape, the shadowgraph is used to measure shape and size . . . minimum and maximum tolerances. The shadowgraph is a projection, greatly magnified . . . on a calibrated screen . . . of the sample.



Schematic of shadowgraph

Here's the step-by-step process:

1. Cold rolled special shape produced by Crucible.

2. The type slug cut from the special shape material.

3. The wings of the type slug are bent down and taper formed toward the edges.

4. The type characters are cold swadged on the solid edge of the bent type slug.

If you have a requirement for special steels—check with Crucible. Feel free to draw on the experience of our metallurgists and engineers. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

CRUCIBLE first name in special purpose steels

52 years of Fine steelmaking

Midland Works, Midland, Pa. • Spaulding Works, Harrison, N. J. • Park Works, Pittsburgh, Pa. • Spring Works, Pittsburgh, Pa.
National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

● There's a K&E slide rule for every purpose. Whether designed to meet the modest needs of the beginner or the exacting requirements of professionals, all K&E rules feature "built in" accuracy and reflect the skill and craftsmanship of America's most experienced slide rule manufacturer.

KEUFFEL & ESSER CO.

EST. 1867

NEW YORK • HOBOKEN, N. J.

Chicago • St. Louis • Detroit • San Francisco • Los Angeles • Montreal

K+E

Drafting, Reproduction and Surveying Equipment and Materials, Slide Rules, Measuring Tapes

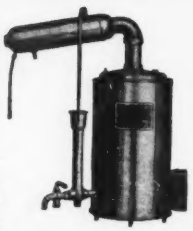
First in

PURE WATER

Since 1878

BARNSTEAD

WATER STILLS



Barnstead Laboratory and Industrial Water Stills are the proven standard of the scientific and industrial world. They produce water of unvarying consistency and unmatched purity. Easy to operate, easy to clean, they provide pure water at low cost.

Over 100 sizes and models to meet any pure water requirement.

★ Barnstead STILL & STERILIZER CO. ★

45 Lanesville Terrace, Forest Hills, Boston 31, Mass.

the atomic clock

(*Continued from page 13*)

calibrated in terms of the U. S. Naval Observatory time signals. These oscillators maintain constant frequency with respect to each other to an accuracy of one part in a billion for intervals up to ten hours and better than one part in one hundred million per day. They can therefore be used to measure the constancy of the atomic clock to this accuracy. This is done by beating the signals from the two sources together at a frequency of 12.5 MC to obtain greater measurement sensitivity. A change of one cycle per second in the frequency of the beat note, as recorded on the frequency meter or on an automatic recorder, indicates a frequency variation of one part in 12.5 million. In recent tests, the Model Two clock maintained a constancy of one part in fifty million for eight days.

The ultimate accuracy of an atomic clock depends on many factors, of which the most important are those governing the width of the spectrum line. Spectrum lines are not infinitely narrow but have a finite width covering a considerable frequency range, since atoms or molecules do not emit or absorb radiation at only one frequency but rather over a narrow band of frequencies. The ratio of a line frequency to its width at the half-power points is called the Q of the line, in analogy to the Q (quality) factor of resonant circuits used in standard radio technique. The Q is a measure of the sharpness of the line and therefore determines its usefulness as an accurate frequency and time standard.

In the case of ammonia, the natural line width determined by the uncertainty principle of quantum mechanics gives a Q of about 10^{10}. If a line width were determined only by the natural lifetime of an excited state in the ammonia molecule, the Q would have the phenomenal value of 10^{13}. However, the line is broadened by other factors which lower the Q to a value of from fifty thousand to five hundred thousand, depending on the temperature and pressure of the gas. This may be compared to Q values of roughly fifty thousand for a good cavity resonator in a microwave circuit and values of one million or so for the best quartz crystals. The ammonia spectrum line thus has a Q approximating that of the best quartz crystals, though much more constant and stable.

The ammonia molecules in the absorption cell are moving rapidly in random thermal motion at an average speed of almost two thousand feet per second at room temperature. When a gas molecule in an absorption cell is approaching or receding from the source of an electromagnetic wave because of its heat motion, its absorption frequency is different from that which it would have if it were standing still. This gives rise to a "Doppler broadening" of the absorption line analogous to the change in pitch of sound as its source approaches, passes, and leaves an observer. Thus, the line width can be reduced slightly by lowering the temperature of the gas (or by using a heavier molecule).

(*Continued on page 32*)

CAPITALIST!

Johnny used to be a laborer. Brother Tim still is.

Both cut lawns. Both used to use customers' hand mowers. Each could do one big lawn a day, and got $2 for it.

Tim spent his $2 on movies and candy. Johnny saved some money, borrowed some more, and bought a power mower. Now he can cut 5 lawns a day, and so makes $10.

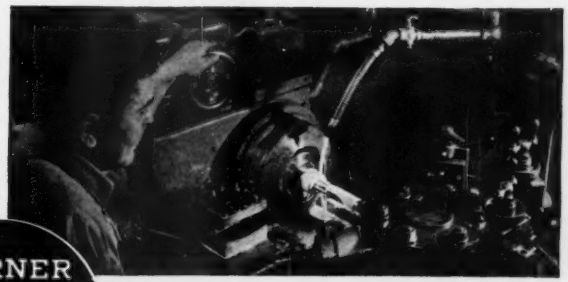
He puts aside $2 a day to pay back his loan, and $1 toward another mower when this one wears out.

He still has seven dollars where he used to have two, and is helping more people get their lawns cut when they want them. Yet some enemies of business would say that that shows Johnny is too big; he should be limited in the number of people he can serve.

These same strange enemies would prevent Johnny from setting aside $1 a day out of his own earnings, to buy a new mower when this one wears out. (Of course, that means Johnny would go back to hand labor at $2 a day, and fewer people would be served—but these strange people don't care about that.)

And some people say Johnny should be forced to share his $7 with Tim so Tim can keep on spending his $2 for movies and candy.

Sound ridiculous? Yes, but every one of these charges and demands is leveled at American business today.



WARNER & SWASEY
Cleveland
Machine Tools
Textile
Machinery

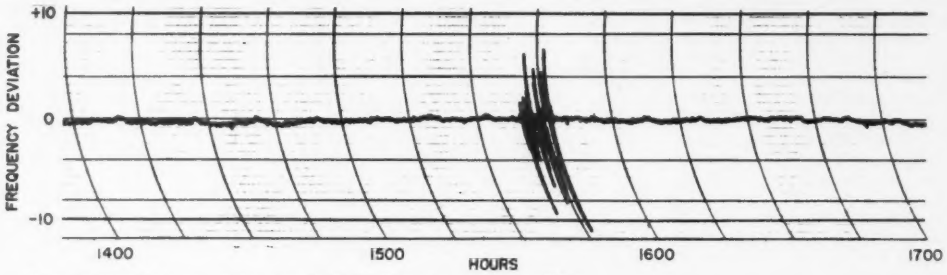
YOU CAN MACHINE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY TURRET LATHES, AUTOMATICS AND TAPPING MACHINES

atomic clock

(*Continued from page 30*)

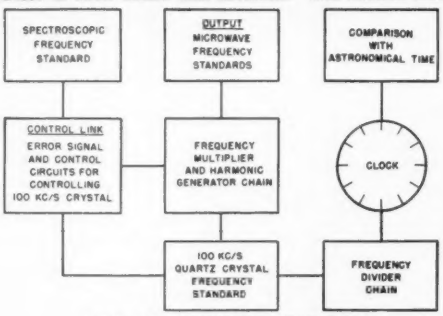
Doppler broadening lowers the Q of the ammonia line to about 330,000 at room temperatures.

Molecular collisions also broaden the absorption line. This broadening occurs because the collisions abruptly terminate the absorption process, causing the molecules to absorb wave trains whose lengths vary in a random way determined by the distribution of time intervals between collisions. A frequency analysis of these wave trains shows a corresponding random distribution of absorbed frequencies, all centering about a mean value determined by the number of collisions per second. In ammonia gas at a pressure of 10 microns there are about one hundred and twenty thousand collisions per second, giving an experimentally measured Q of forty-five thousand for the absorption line used.



Plotted are the deviations of the atomic clock in parts per ten million

Improvement of the accuracy of the atomic clock will make it useful in several fields of pure and applied science. The lengths of the mean solar day, used in astronomical measurements, fluctuate as much as one part in 20 to 30 million, because of variations in the rate of rotation of the earth on its axis. The variation in present time standards, due to these fluctuations, causes errors in the location of heavenly bodies and in studies of their orbits and motions. The atomic clock offers the possibility of an invariant master clock against which the variation in the earth's time-keeping could be measured. An absorption cell on an atomic clock could, for some purposes, take the place of an astronomical observatory.


SPECTROSCOPIC FREQUENCY STANDARD
OUTPUT MICROWAVE FREQUENCY STANDARDS
COMPARISON WITH ASTRONOMICAL TIME
CONTROL LINK
ERROR SIGNAL AND CONTROL CIRCUITS FOR CONTROLLING 100 KC/S CRYSTAL
FREQUENCY MULTIPLIER AND HARMONIC GENERATOR CHAIN
CLOCK
100 KC/S QUARTZ CRYSTAL FREQUENCY STANDARD
FREQUENCY DIVIDER CHAIN

SIMPLIFIED BLOCK DIAGRAM OF NBS ATOMIC CLOCK

The atomic clock should permit improvement in astronomical time standards in a way impossible with electric-pendulum or quartz-crystal clocks. It thus opens the possibility of improving the precision of knowledge of the length of the year, that is, the time it takes the earth to revolve once in its orbit around the sun. This is independent of the time it takes the earth to rotate once on its axis — the mean solar day. Measurements could then determine whether the mean sidereal year is more constant than the mean solar day, as some astronomers believe may be the case.

Although the use of atomic time presents advantages in many fields of science, it will always be necessary for some purposes to have astronomical time standards. This is because the pointing of a telescope depends on the orientation of the earth at the instant of observation, in other words, on astronomical time measurements which derive from the motion of the earth.

The National Bureau of Standards is investigating several different methods of attack on the problem of atomic frequency and time standards. A Model 3 ammonia clock is now under development using new methods employing a FM principle, new tubes and methods to provide reliable running times of as long as six to twelve months minimum. Under way are two clocks in which quartz-crystal oscillators are controlled respectively by ammonia in an absorption cell and by cesium using atomic beam techniques. A third unit is based on an atomic oscillator to be controlled by ammonia; a fourth development is the investigation of nuclear electric quadrupole lines in crystals to provide portable standards free from aging and susceptibility to mechanical shock.

It looks like the problem of measuring time is about licked.

---

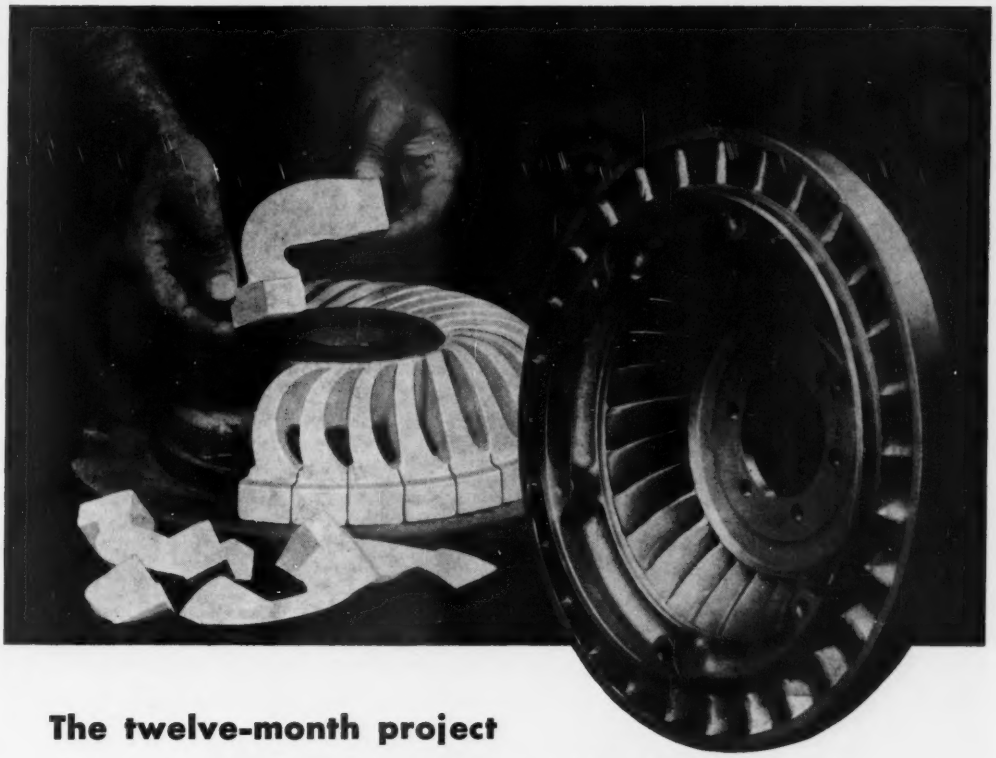
scientific method

(*Continued from page 28*)

in the conjecture we are dealing also with sums, an additive aspect. There is difficulty relating the two levels of structure involved.

One final example of strata structure is in order. This has to do with logical systems that are not too restricted. This is the result proven by Godel that a statement about a logical structure may be true when viewed from a larger structure, but it may be impossible to prove the assertion true without extending our concepts. As I have worded it, the assertion is inaccurate; in particular, logical systems cannot be identified with what I have called "structures" here, although they are examples of structures.

It has often been observed that one must know a lot of science in order to understand the limitations of the scientific method. What is the scientific method? It is the theory of the relationships between the ideas that are accepted by scientists. As such, it has both a technical and a humanitarian aspect. Cross structure pays attention to the first aspect only. Let no one ignore the other!



The twelve-month project that improved no-shift driving

ANOTHER ALCOA DEVELOPMENT STORY:
One automobile manufacturer set out to improve his fluid coupling to the Nth degree.

Torque converters had been made by machining cast or forged blanks, or by assembling stamped parts. But these engineers wanted better performance. This meant their converters must be stronger, lighter, more intricate. They asked, "Can we do it in aluminum?"

Our Research specialists saw the chance to show the economy of a little-known process called plaster casting. A process in which plaster, instead of sand, is used for cores to provide more intricate and smoother castings—castings that require no machining of the blades. It promised results that might even exceed the auto maker's requirements.

Final design refinements were made. Then we cast the first samples. They came from the molds smooth and clean—perfect in detail.

While the auto manufacturer machined them to finished dimensions, we set up to test them for strength at high speeds. Coating the parts with brittle lacquer, we spun them in our whirlpit up to 10,000 rpm—over twice their normal operating speed. Cracks in the brittle lacquer told us where strains concentrated. Designs were modified. New samples cast. Tests repeated. The final castings are smooth, faithful in detail, exceed every strength requirement.

This is typical of the development jobs we do at Alcoa. Others are under way now and more are waiting for mechanical, metallurgical, electrical, chemical and industrial engineers having the imagineering skill to tackle them. Perhaps you may be one of those men.

ALUMINUM COMPANY OF AMERICA
1825 Gulf Building • Pittsburgh 19, Pennsylvania

A business built on co-operation

ALCOA®

ALUMINUM COMPANY OF AMERICA

How Honeywell Controls help bring you a clear picture of the Bob Hope Show

You often hear folks remark on the clear, undistorted TV pictures they enjoy. "It's almost like having the entertainers in your living room!" they say.

These lifelike pictures are no accident—they call for the greatest care in producing your TV set. For example, consider how picture tubes are built. At half a dozen manufacturing stages, a tiny difference in temperature or vacuum can make a big difference in picture quality. So, many makers control their ovens and other equipment with supersensitive *electronic* instruments built by Honeywell's Industrial Division.

And this is just one of many important fields where Honeywell controls play a vital role in the modern world.

Today, for example, fabulous new controls for aviation, guided missiles and atomic energy are being developed by the men in our expanding engineering and research sections. Many of these workers are keen-minded young men only recently graduated from college.

Equipped with the latest scientific instruments, they find their work at Honeywell often calls for fascinating research in the realm of pure science.

There's real opportunity for engineers at Honeywell—for this is the age of Automatic Control, everywhere you turn.

And Honeywell has been the leader in *controls* for more than 60 years!

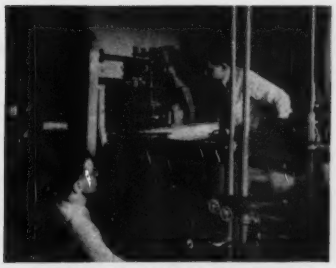
America lives better—works better with Honeywell Controls

For information about opportunities in our engineering and research departments write us, stating your qualifications. Depending on the location you prefer, send your letter to Personnel Dept., Minneapolis-Honeywell, Minneapolis 8, Minn.; Personnel Dept., Minneapolis-Honeywell, Brown Instruments Division, Philadelphia 44, Pa.; or Personnel Dept., Minneapolis-Honeywell, Micro Switch Division, Freeport, Ill.

MINNEAPOLIS **Honeywell**

First in Controls

THE DU PONT DIGEST



SEEKING *new ways to coat plastic on wire: Carl Hellman, B.S.Ch.E., Syracuse '50; and J. M. McKelvey, Ph.D.Ch.E., Washington '50.*

Ch. E's at Du Pont

[SECOND OF A SERIES]

The fields of research and development invite ingenuity of the chemical engineer

Research and development work in chemical engineering often overlap at Du Pont, except where the research is fundamental.

The chemical engineer occupied with fundamental research is chiefly concerned with basic studies of unit operations and processes involving reaction kinetics, thermodynamic properties of fluids, high-pressure techniques, equilibrium studies, heat transfer and the like. Such studies often lead to lower-cost manufacturing processes. Some recent projects in fundamental research have been:

1. A study of fluidized catalyst reaction units including degree of fluidation, temperature uniformity, catalyst activity and life, and conversion of feed gases.

2. Studies of the fundamental transfer relations between phases, for instance, gas and liquid, in reacting materials.

Apart from the chemical engineers engaged in fundamental research, there are many groups working in applied research and development. In fact, this is the major part of the chemical engineering work done at Du Pont. Here are examples of the literally hundreds of unusual problems they have solved:

1. Designing equipment for producing pure silicon at 1000°C. (Though one of the starting compounds is highly corrosive, only spectroscopic traces of impurities can be tolerated.)

2. Developing a high-pressure liquid-phase process to replace the standard dry method of producing sodium azide formerly employed.

3. Designing a continuous flow, gas-liquid reactor for use in making a fiber intermediate under pressure.

4. Developing, from laboratory research results, a process for large-scale production of complex polymeric materials used in the manufacture of color photographic film.

These examples can only hint the variety and originality of problems constantly arising at Du Pont. They indicate the challenge as well as the broad opportunity awaiting the talents and ingenuity of the young chemical engineer who wants a career in research and development.

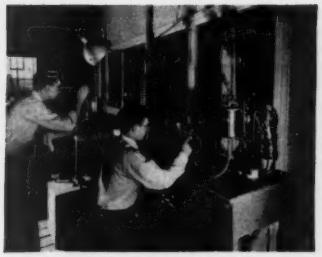
NEXT MONTH—The chemical engineer's role in plant operation at Du Pont will be discussed in the third article in this series. Watch for it!

SEND FOR your copy of "The Du Pont Company and the College Graduate." Describes opportunities for men and women with many types of training. Address: 2521 Nemours Bldg., Wilmington, Delaware.

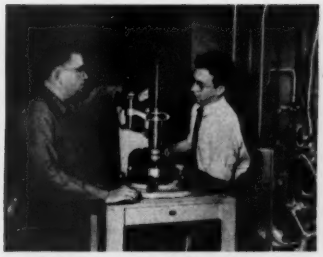
DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Entertaining, Informative — Listen to "Cavalcade of America," Tuesday Nights, NBC Coast to Coast



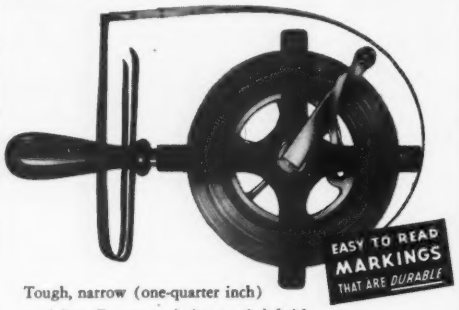
MEASURING *pore-size distribution of porous media used in filtration: Harold P. Grace, B.S.Ch.E., Univ. of Pennsylvania '41; and Nym K. Seward, B.S.Ch.E., Lehigh U. '47.*



INSPECTING *a new type of high-pressure reactor: Robert J. Stewart, B.S.Ch.E., Rensselaer Polytechnic Institute '50; and Henry Smithies, M.S.Ch.E., University of Michigan '50.*

STUDYING *plate in stainless-steel tower used to determine efficiency of designs: C. M. Gamel, Jr., S.M.Ch.E., M.I.T. '48; and J. B. Jones, M.S.Ch.E., University of Michigan '46.*

LUFKIN "Western" chrome-clad steel tape—accurate, durable



Tough, narrow (one-quarter inch) steel line. Easy-to-read chrome-clad finish, has jet black markings on chrome-white background. Line is extra heavy (.020" before multiple plating). Marked 10ths and 100ths ft., or feet, inches and 8ths. An especially durable tape mounted on a sturdy frame with extra long, self locking, winding device and hardwood carrying handle. Furnished with 2 leather thongs.

BUY LUFKIN TAPES, RULES, PRECISION TOOLS at your Technical Supply House

THE LUFKIN RULE CO. • SAGINAW, MICHIGAN
132-138 Lafayette St., New York City • Barrie, Ont.

154

Summa Cum Laude ... *in the science of anti-friction*

Wheels turn faster and men work more efficiently in every industry because of anti-friction bearings. And every industry knows and uses SKF Ball and Roller Bearings.

This acceptance of SKF has been built on its ability to help put the right bearing in the right place.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

SKF
BALL AND ROLLER BEARINGS

upper limit

(*Continued from page 15*)

that these visitors are responsible for all this mischievous nonsense."

"Visitors, Sir?"

"Yes, come forward immediately with Nentz, and bring your suits."

"Yes, Sir!" The communication screen blanked.

"They were at two hundred miles distance, ten seconds ago, Sir. They are approaching in a collision orbit. Contact time: nine minutes."

The two technicians shuffled into the control room with their suits. They both gazed at the rapidly approaching new-comer. It was a swelling sphere in the port visor screen. Growing, and growing . . . contact orbit.

"They are going to collide with us!" shouted Nentz, who had been peering intently at the port visor. Mackley automatically swung about and punched the emergency acceleration button on the control panel. Of course, nothing happened. The dark spherical bulk blotted out the faintly luminous background of the galaxies, and seemed to crush itself into the sides of the *Upper Limit*. Nothing happened. The mass came to rest against the sides of the *Upper Limit*. A gentle tremor ran through the sides of the Earth ship and a distant, disconcerting sigh of an opening airlock in the ship could be heard. An eye on the panel suddenly winked into a bright orange "vacuum" signal before Mackley's astounded gaze, and as he sat immobile in complete surprise, the orange eye paled, and shaded off into a soft green denoting "pressure."

"What," gasped the incredulous Mackley, "in heaven's name is going on around here? Why those damnable insignificant meddlers! Pirates! — Pirates in deep space . . . a hundred and twenty-five thousand . . ."

He stopped in mid-sentence. The sound of steps . . . human steps were heard in the corridor outside of the control room. The steps shuffled to a halt. All breaths were sharply drawn in and held.

The door swung slowly open.

"What . . ." Words wouldn't come.

A perfect image of Mackley stood in the control room doorway. Tall, erect, greying hair, and that same expression of amazed, unutterable emotion stamped upon its face.

"What's the meaning of this!" shouted Mackley hoarsely.

The image wavered, then steadied. As Mackley spoke his words, it took on the movements of the facial muscles in perfect synchronism with Mackley's.

"Silence, please!" ordered the specter, facial muscles motionless. Its voice seemed to issue from all quarters of the room at once. "This seeming image of one of you is only a visual superposition upon my own form. It is to keep the confusion and natural fear in your minds down to a reasonable minimum for the next few minutes. It is something upon which to focus your senses and direct your mental efforts." The image wavered slightly, and a wave of horror swept through the minds of the Earthmen as a shadowy glimpse of their visitor was received for a brief instant. It quickly solidified, and the horrified expression of Mackley's countenance was on its face again.

"You have," began the intruder without further preamble, "reached your upper limit of exploration in this universe. You cannot and will not proceed any

(*Continued on page 40*)

how wet?

Today, Limestone . . . processed to Carbide; then Acetylene produces plastics . . . synthetic rubber for bathing suits . . . tires . . . garden hose.

how dry?

Paint protects steel. Better if prime-coated surface is dehydrated. The Oxyacetylene Flame burns out moisture . . . paint clings closer — lasts longer.

AN AIR REDUCTION PRODUCT

at the frontiers of progress you'll find

Wet as a bathing suit . . . dry as a fire. Carbide . . . and Acetylene are the chemical blocks upon which today's miracle products are built. Combined with oxygen they form one of the world's most versatile teams for cutting, welding and conditioning metals.

Carbide . . . and Acetylene are just two of the many products of the Air Reduction corporate family . . . a group that contributes to practically every phase of American life — and industry . . . serving such diversified activities as medical therapy and soft drink carbonation . . . flame cleaning and synthetics.

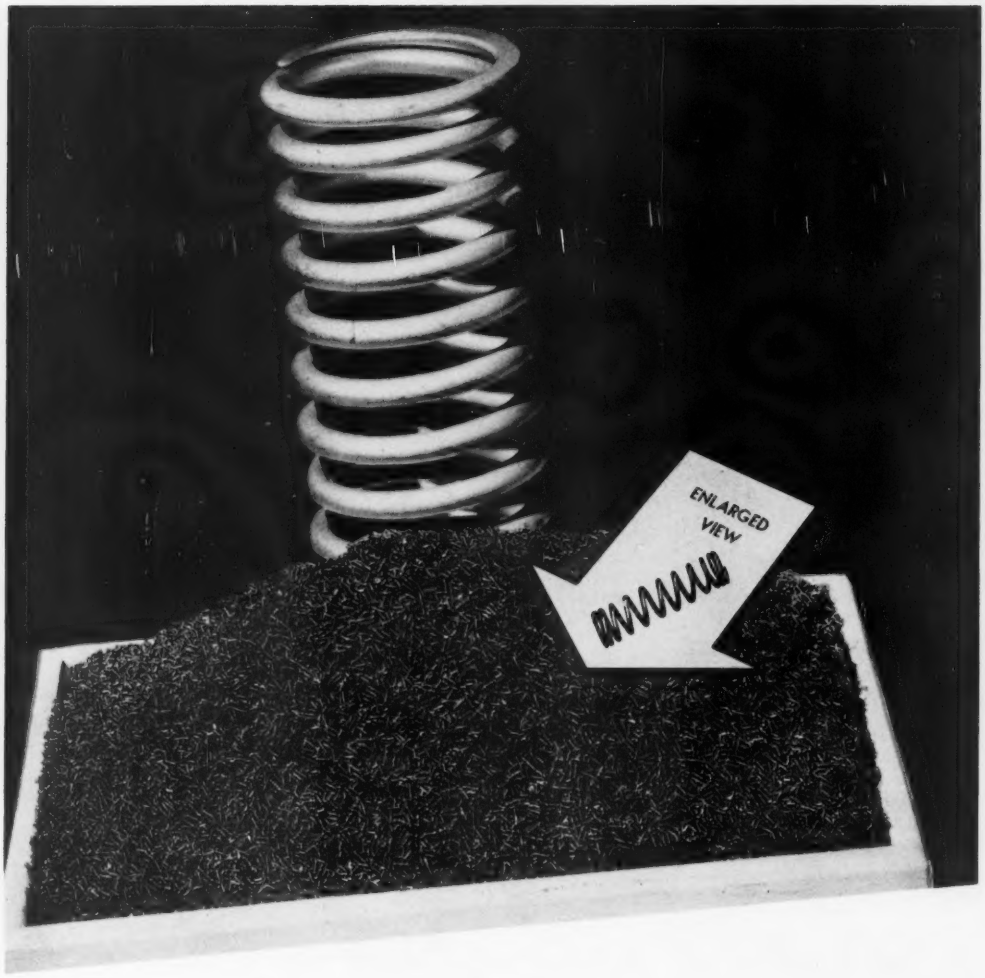
In fact, wherever progress is racing ahead to new frontiers, you find an *Air Reduction Product.*

AIRCO® **AIR REDUCTION COMPANY, INCORPORATED**

Divisions of Air Reduction Company, Incorporated,

AIR REDUCTION SALES COMPANY, AIR REDUCTION PACIFIC COMPANY, AIR REDUCTION MAGNOLIA COMPANY . . . *Industrial Gases, Welding and Cutting Equipment* • AIRCO EQUIPMENT MANUFACTURING DIVISION • NATIONAL CARBIDE COMPANY . . . *Calcium Carbide* • OHIO CHEMICAL & SURGICAL EQUIPMENT CO., OHIO CHEMICAL PACIFIC COMPANY . . . *Medical Gases — Apparatus — Hospital Equipment* • PURE CARBONIC COMPANY . . . *Carbonic Gas and "Dry-Ice"* • AIRCO COMPANY INTERNATIONAL . . . *Export* • AIR REDUCTION CHEMICAL COMPANY

1=177,000



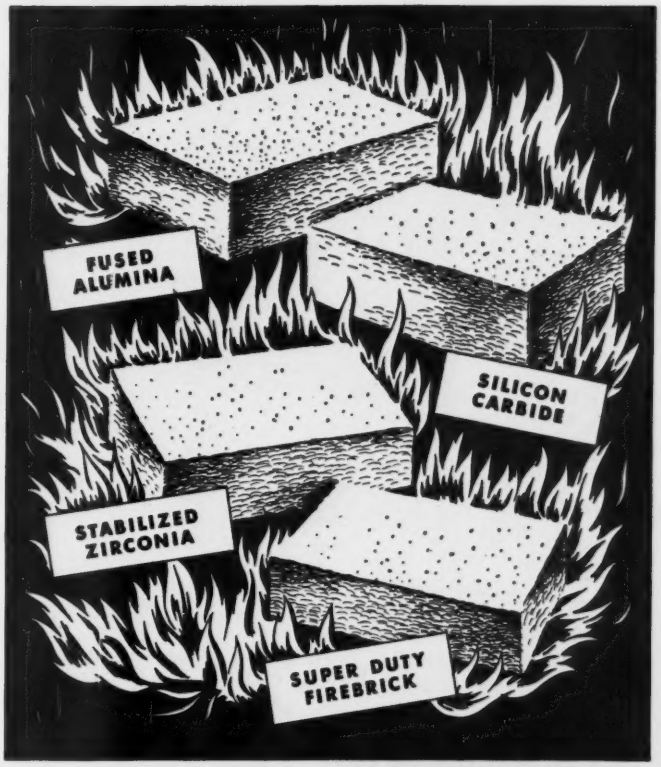
We wouldn't recommend counting them, but there are 177,000 compression springs piled in the tray above. Their total weight is 2½ pounds. By comparison, the single large compression spring also weighs 2½ pounds. Extremes of spring usage like these are an everyday occurrence—in greater or lesser degree. They are the reasons why springmaking is one of the most interesting and stimulating industries.

Wallace Barnes Springs

Springmakers for four generations

Bristol Connecticut

Which of these Refractories *withstands the* Highest *temperature?*



If you answered "Stabilized Zirconia*" you're right up to the minute on the latest developments in the refractory industry. Norton Fused Stabilized Zirconia . . . an amazing new refractory . . . withstands temperatures up to 4500°F. Because it makes higher temperature ceilings possible, Norton Stabilized Zirconia opens the doors to new technical advances in the processing field . . . has already speeded up gas synthesis production by a profitable margin.

Other Extraordinary Properties

No other refractory offers such an unusual combination of properties. Norton Stabilized Zirconia has a *surprisingly low thermal conductivity.* In spite of the fact that its specific gravity is twice that of fire clay brick, its thermal conductivity is only 6 (English Units) as compared with fire clay's 12, fused alumina's 20± and silicon carbide's 50+.

Even more amazing is the *electrical resistivity* of Norton Fused Stabilized Zirconia . . . ranging from 2300 ohm-cm at 1300° F to 0.37 ohm-cm at 4000°F. Yes, it's just the opposite to the usual rule that resistance increases with the temperature.

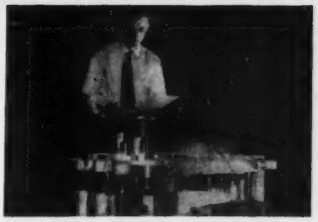
Equally valuable to processing industries is the *chemical stability* of Norton Stabilized Zirconia, manifested in its ability to resist both oxidizing and reducing atmospheres at high temperatures and its chemical inertness in contact with titanates.

Thinking of Your Future?

First to produce Fused Stabilized Zirconia in commercially significant quantities, Norton keeps on "making better products to make other products better" through constant work on new developments. To do this requires new ideas and fresh approaches in the field of research . . . a hint to young engineers and chemists. When you think of your future, think of Norton.

New Bulletin

describes the amazing properties of Norton Fused Stabilized Zirconia in full detail. Write for a free copy.



Neil Ault, Ph.D., Ohio State '50, measures the resistance to deformation of Crystolon* (SiC) refractories at high temperatures in multiple load test furnace.

*Trade Marks Reg. U. S. Pat. Off. and Foreign Countries

NORTON

TRADE MARK REG. U. S. PAT. OFF.

Making better products to make other products better

ABRASIVES · GRINDING WHEELS · OILSTONES · ABRASIVE PAPER & CLOTH · GRINDING & LAPPING MACHINES · LABELING MACHINES · NON-SLIP FLOORING · REFRACTORIES · CERAMIC SURFACE PLATES · BORON CARBIDE PRODUCTS

NORTON COMPANY, WORCESTER 6, MASSACHUSETTS

BEHR-MANNING, TROY, N. Y. IS A DIVISION OF NORTON COMPANY

An S.S.White Flexible Shaft
provides the "muscle" for a unique airborne duster
The economics of Flexible Shafts
Courtesy Bell Aircraft Co., Buffalo, N. Y.

When the manufacturer of this crop-dusting helicopter wanted to transmit power from the accessory gear box to the insecticide pump, mounted some distance away, he chose an S.S.White flexible shaft to do the job. As the diagram shows, the shaft provides a simple one-piece coupling that can be readily run around intervening struts and frames.

* * * *

Many of the problems you'll face in industry will involve the application of power drives and remote control with the emphasis on low cost. That's why it will pay you to become familiar with S.S.White flexible shafts, because these "Metal Muscles"® represent the low-cost way to transmit power and remote control.

SEND FOR THIS FREE FLEXIBLE SHAFT BOOKLET . . .

Bulletin 5008 contains basic flexible shaft data and facts and shows how to select and apply flexible shafts. Write for a copy.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. C, 10 East 40th St.
NEW YORK 16, N. Y.

upper limit

(*Continued from page 36*)

farther than this region of space. You will immediately turn about, and return to your earth, and warn its people that any penetration beyond this limit will bring immediate destruction upon them . . . the whole Earth."

"What sort of dramatic idiocy is this! What sort of monstrous joke is someone playing on us!" said Mackley in perfect unison with his image. "This cannot be happening!"

"I assure you, Mackley, this *is* happening, and if this message is not brought back to Earth and received with acceptance, we will be obliged to complete our threat of destruction." The form in the doorway grimaced and writhed throughout the speech, reflecting the utter disbelief of Mackley, and was complete with a surging redness of waxing fury. Mackley and his image drew a hand weapon simultaneously from their hip pockets. Three thunderous shots in quick succession. Mackley slumped from his chair, crumpling on the floor of the control room, steaming weapon still in his hand. Three whining steel pellets from the pistol ricocheted about the walls of the room and finally found rest. Mackley lay black and charred upon the floor, a burned-out shell of carbon and lime.

The four humans stood, transfixed.

The image of Nentz wavered in the doorway. The face was pale with growing horror, hands nervously twitching with the zipper catches on its space suit. It opened its mouth to speak, but the words came from the whole room. "This useless carnage can be avoided if you four can grasp the message I will attempt to give. I will assure you four safe passage to your system."

"Can't we reason this out together . . . tell us why you demand our confinement to our galaxy . . . why can't we go out farther than this?" pleaded Shaeffer.

His image turned toward him with composed expression. It spoke through tightly closed lips, and its voice issued from nowhere particular in the room. "I have the obvious choice of informing you," started the image of Shaeffer staring with growing horror at its original, "of the real reason for this seeming idiotic drama, or of merely removing the life from all of you. There are men on Earth that can grasp this message if you relate it to them, and they will know what to do. But, if you return, *we* must help you return. The reason for our intervention is beyond the power of your kind to grasp, and I choose the alternative of impressing you with the sense of immediate urgency of returning to your world, and spreading the message that you cannot and will not go beyond this region of space . . . you will face inevitable destruction if you disobey this order, either by our hands, or possibly your own. It will be our necessity to exterminate the civilizations in your galaxy if you deem to ignore this order. You have no choice now but to turn about and return to your planet."

"Sweter, can't you think of something to say to him . . . this . . . entity?" The image took on a nondescript composite of the two men as they faced each other. Nentz and Arrane stood aghast at this new display.

"Let me say this," began the wavering composite. "It is in connection with this new space propulsion unit you have so carelessly utilized to come out this far. . . ."

"But what does that have to do with the destruction of Earth, and of our collective systems throughout the

(*Continued on page 42*)

FLAT SPRING STEEL

Manufacturers count on Roebling for absolutely uniform quality

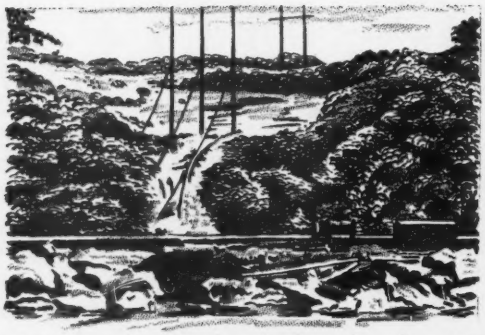
FOR FLAPPER VALVES, shoe shanks, measuring tapes! For steel rules, curtain springs, snap springs, lock springs, drop wires, sinker steel and a thousand and one other exacting uses, Roebling high carbon flat mechanical spring steel is unsurpassed.

Roebling has one of the largest specialty wire mills in America, and our complete facilities for producing flat spring steel give us positive control over every phase of production. The final product is dimensionally and mechanically uniform . . . cuts down machine stoppages . . . minimizes rejects. And Roebling flat spring steel is made in a wide range – annealed, hard rolled untempered; scaleless tempered; tempered and polished, blued or strawed.

Roebling technicians are always glad to help choose the *right* flat spring steel for top efficiency in any given application. John A. Roebling's Sons Company, Trenton 2, N. J.

ROEBLING

Atlanta, 934 Avon Ave ★ ***Boston,*** 51 Sleeper St ★ ***Chicago,*** 5525 W. Roosevelt Rd ★ ***Cincinnati,*** 3253 Fredonia Ave ★ ***Cleveland,*** 701 St. Clair Ave, N.E. ★ ***Denver,*** 4801 Jackson St ★ ***Detroit,*** 915 Fisher Building ★ ***Houston,*** 6216 Navigation Blvd ★ ***Los Angeles,*** 216 S. Alameda St ★ ***New York,*** 19 Rector St ★ ***Odessa, Texas,*** 1920 E. 2nd St ★ ***Philadelphia,*** 230 Vine St ★ ***San Francisco,*** 1740 17th St ★ ***Seattle,*** 900 1st Ave, S. ★ ***Tulsa,*** 321 N. Cheyenne St ★ Export Sales Office, ***Trenton, N. J.***



The first submarine installation of a pipe-type cable system was recently installed under the Hudson River at Poughkeepsie, N.Y. Three cables, each nearly ¾-miles long, were simultaneously pulled into a six-inch welded steel pipe laid across the river bottom. The pipe was then filled with oil maintained at 200 lbs. pressure, enabling a 110,000-volt power circuit to cross the river safely.

This kind of system is called Oilostatic—a design which has long been first choice among utilities for handling large blocks of power by means of a high-pressure pipe-type cable system. Increased circuit reliability and savings on installation and maintenance costs are realized.

Oilostatic's new role as a submarine cable is typical of the significant contributions to better electrical service made by Okonite engineers.

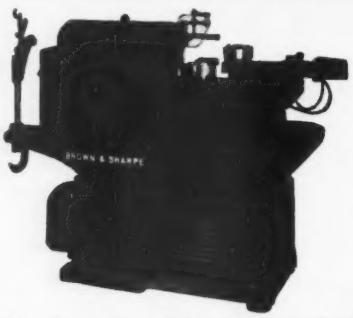
• • •

Tough jobs are the true test of electrical cable . . . and installations on such jobs usually turn out to be Okonite.

OKONITE *insulated wires and cables*

8789

NEW BROWN & SHARPE HAND SCREW MACHINES



Handle Short-Run Jobs More Profitably

Nos. 00, 0 and 2 Brown & Sharpe Hand Screw Machines produce small-quantity bar-stock and second-operation jobs with high economy and efficiency. Write for detailed literature on these modern cost-cutting machines which take stock from 3/16" to 1" diameter. Brown & Sharpe Mfg. Co., Providence 1, Rhode Island, U.S.A.

BROWN & SHARPE

upper limit

(*Continued from page 40*)

whole galaxy?" asked Sweter of his rapidly focusing image.

The image stood, wavering in the doorway. It was silent. It transformed into the form of Shaeffer, and fixed him with a shrewd, calculating stare, body completely immobile. The presence beneath the human shell was a wavering hint of undefinable horror for the four men. It appeared to be surveying them with the terror-filled eyes of each man, reflecting instantly the outward appearance of each as it scanned the original.

"I will show you, but it will be to no avail . . . I must be brief." The being paused. Silence filled the room. Suddenly each man was filled with a picture that staggered the orientation of his mind. Space, endless space, flattened into an infinite plane. There was the solar system. Then, each man's attention was forced to an incredibly remote place on the infinite plane. The plane began to distort there, and move as if a pair of tremendous fingers had puckered a bit of the elastic material of the plane. The pucker in the space was pulled all the way over to the site of the solar system. *That is what your drive did to space* (the voice filled their minds) *now watch!* A little red spot, obviously the *Upper Limit*, attached itself to the pucker, and with a blurring whipping action, the pucker snapped back across the tremendous gulf, and started to vibrate to rest. But tremendous waves and ripples whipped out from the place where the ship had landed, and they spread out from the center with a terrifying velocity. They swept across the barren stretches of the plane, and soon were upon populated star regions which shone as if they were puffs of phosphorescent powder which had been sprinkled upon the infinite plane. As soon as the waves crossed the regions, they winked into darkness. *Just as Earthquake ground waves destroy your earthly dwellings, so does this disturbance by your ship destroy matter built into space.* The waves travelled onward, carrying destruction in their wake. But, as they moved onward, they began to attenuate in amplitude, and soon, after an inconceivable distance from the *Upper Limit*'s site, began to fade. The picture in their minds faded. They were again aware of the being in the doorway. "What sort of nonsense are you trying to give us?" shouted Sweter.

"None; the radius of destruction is a hundred thousand light-years. We detected the distortion as you were preparing to go into the drive back on the Earth. We rushed to the site of your surfacing. And, as you surfaced, we temporarily immobilized your craft, and simultaneously absorbed the distortion energy, and are holding it now . . . we cannot hold it much longer. We will use it to help you safely return to your Earth to warn your peoples of the deadliness of the drive."

"How can we believe you?" asked Shaeffer. "Why didn't the drive destroy the Earth when we made our test run?"

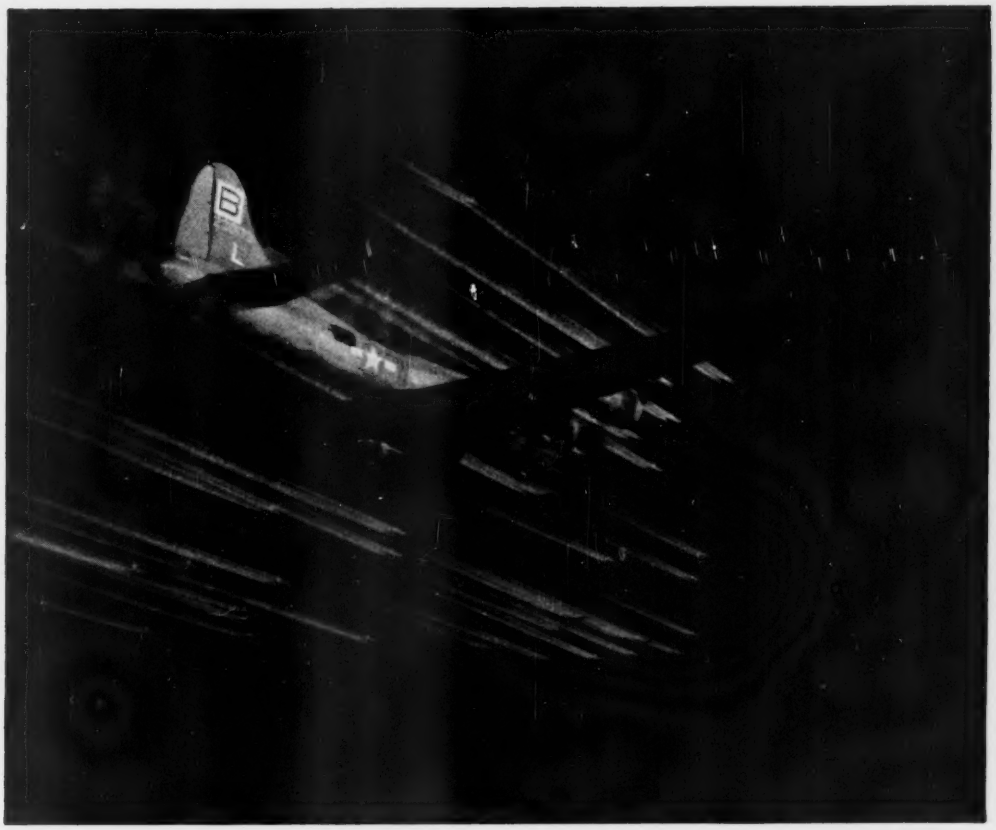
"That distance was well below the critical distance. Only when the fabric of space is disported beyond its limit of . . ."

A tremor ran through the floor of the ship.

I cannot waste any more time, the limit is almost over . . . I have now no choice but to . . ."

Shaeffer, who had been watching this restless behaviour during the past fleeting seconds, had been intently concentrating on the form before him, and watching its every minute action. At the last sharply

(*Continued on page 44*)



We hired an engineer over Berlin

"The Boeing Flying Forts came through a wall of flak and fighters that night to hit Berlin right on the nose. They never let us down—not then or on any of the raids to come. I was proud to fly the old Boeings. Now I'm prouder still to be on the great engineering team that designs the new ones."

Boeing engineers feel that way. And they'd be honored to have you join them as they pioneer in dramatic new fields of aviation.

The steady growth of Boeing's Engineering Division over the past 35 years is an index of its stability. There's great work to be done here in all phases of aircraft design. Boeing engineers are now working on such truly exciting projects as the world's hottest jet bombers, the B-47 and the B-52; on secret guided missile programs, on the new Boeing gas turbine engine and other revolutionary developments.

At Boeing you'll find some of the world's best research facilities and you'll work with the men who have helped establish Boeing's world leadership in the fields of aviation research, design and engineering.

You can live in the Pacific Northwest, at Seattle; or, if you prefer, you can settle in the Midwest, at Boeing's Wichita, Kansas, Division. Your inquiries will be referred to the plant of your choice.

So plan now to build your career at Boeing after graduation. Salaries are good, and they grow as you grow. Boeing has present and future openings for experienced and junior aeronautical, mechanical, electrical, civil, electronics, acoustical, weights and tooling engineers for design and research; for servomechanism designers and analysts; for physicists and mathematicians with advanced degrees.

For further information, consult your Placement Office, or write:

JOHN C. SANDERS; Staff Engineer—Personnel
Boeing Airplane Company, Seattle 14, Washington

BOEING

upper limit

(*Continued from page 42*)

voiced order of the entity, he blurred into galvanized motion, performing a bone-cracking dodge to the center of the room, and drawing his pencil-shaped hand weapon at the same time. Nentz, Arrane, and Sweter, senses keyed to an incredible pitch of acuteness, instantly sensed Shaeffer's gambling move, and dropped to the floor, drawing and aiming their hand-weapons during the same instant of time.

A thundering crescendo of crackling, screaming sheets of electrical flame from the weapons of the men seared and splashed against the figure in the doorway. Counter fury emanated from the crumpling, liquefying form. In the tumultuous clamor of this instantaneous and entirely unexpected motion upon the part of the Earthmen, the emergency alarm above the control panel added its raucous, clamoring roar; the "pressure" light on the panel flashed into bright orange . . . the lock had been evacuated. Out in the depths of space, the alien space ship had leaped from the flanks of the ship of Earth and before it was more than three diameters away, it flashed into a brief, unbearably brilliant ball of flame. Then, just as quickly as it had begun, the holocaust subsided, and the forms of the Earthmen lay upon the floor of the control room, and a mass of liquefying matter spread out in a viscous, ragged pattern from the control room doorway.

The man opened his eyes, and focused them upon the stained, smudgy walls of the room. He lay on his back, motionless. Only his eyes moving about, trying to obtain a feeling of perspective, and his mind trying to reorient itself. He felt the cold, unyielding floor beneath him, and the motion of his exploring hand disturbed a thick, evil smelling viscous fluid in which he lay. Feeling returned, and an acute sense of pain coursed through his charred body. Then in a flash, like a sweeping tide of water, memory returned, and with it, a new and awful sense of urgency.

Shaeffer moved his arms, raised them exploringly to his body, and winced at the terrible pain of the burns. He relived the unutterable confusion and hell of those last, tension-torn moments with the intruder . . . the intruder was dead . . . on the floor. Shaeffer turned and surveyed the charred bodies of Captain Mackley, and of Nentz, Arrane and Sweter. A jellying mound of viscous matter in the doorway arrested his attention and the sense of urgency swept anew through his mind.

What a mad, ridiculous, and horrifying episode this experimental voyage had transformed itself into. His mind scanned the remembered incidents: The stalling and refusal of the ship to go under was when it all started. The visitor boldly appearing from nowhere. The moments of ridiculous drama of the fate of worlds. Mackley's death. The space drive. It said the space drive we were using was the cause of the intervention. . . . Why? . . . The visitor, despite his apparently tremendous superiority, he reflected, was still unable to conceal a mortal, or unmortal fear of the drive . . . and yet it bickered, and wanted to dissolve the problem with words, with threats to the Earthmen who held the drive in their possession. . . . The Drive.

What did he know about the drive? Nothing very much, except for the preflight training given him as a matter of routine hypnopaedic drill. He tried to recall images from the wells of his memory patterns on the functioning of the ship. He recalled the equation of the drive principle, but he was not trained in the logical procedures that would allow him to deduce any of the implications of the drive, physical or otherwise. Only several useful corollaries came to his mind . . . bits of information about the navigational procedures and the effects of the drive field of instrumental visual fixes on the stars. The analogies of the alien's picture show concerning the destructive nature of the drive completely eluded him. But now the sense of urgency to return to Earth swept through him anew. It was a desire that was beyond his normal capacity to fulfil, to want to return to Earth . . . with this ship. The alien had put that desire there. Painfully, he regained his footing on the scarred, slippery floor, and scraped and shuffled his way down the control room corridor to a tiny infirmary. He administered the horrible, scarred wounds, that were clotted with hair, and bits of space suit. He did the best he could, more later. Now, he must head back to Earth, and warn them of the encounter. They will have an answer to the drive problem back on Earth.

He shuffled painfully into the scarred control room. The blue, soft panel lights eased the sharpness of the fallen horrors around him. He seated himself upon the control seat which was grimed from the charred flesh of Mackley's body . . . the hasty, quick tempered, good old fool, Mackley.

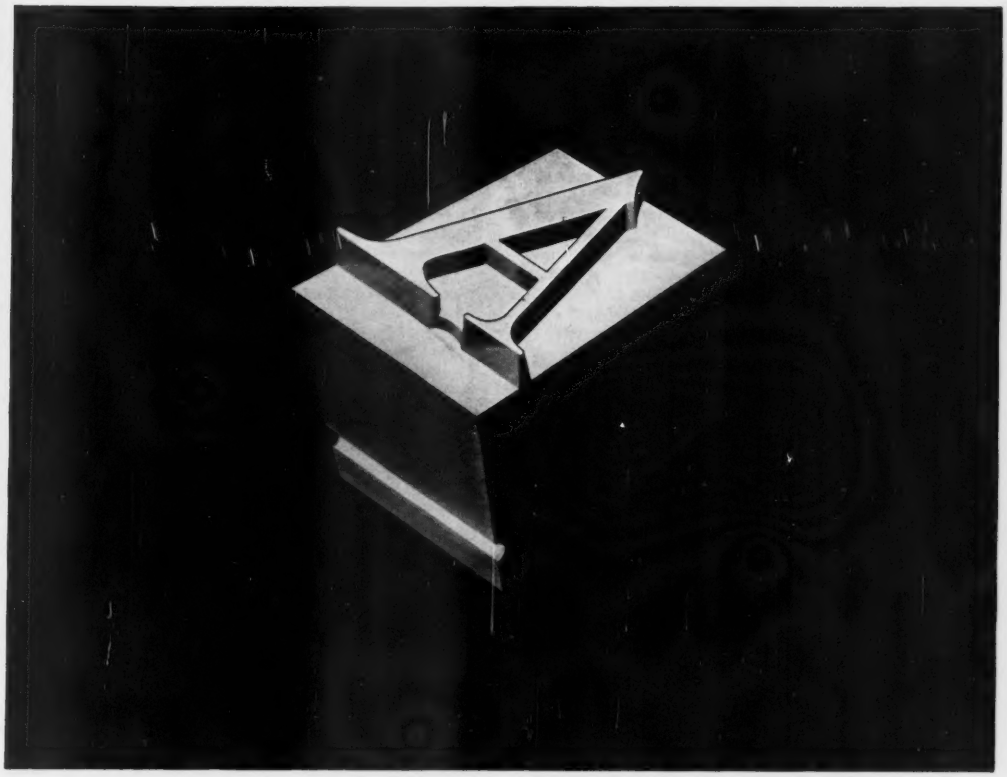
The ship . . . will it move? Move under, that is, into subspace. With trembling, pain-seared fingers, he depressed the activator studs that would bring the power room's submerging units into life . . . the only things that would ever make it possible to leave this inaccessible, remote corner of time and space.

The answering flicker, the friendly winking of the response lights on the board smiled a smile of salvation to the man in the control seat. They told him in bright colors that the submerging units were waiting, humming their unfelt unheard song of power patiently; waiting to surge into invisible hellish life at the pressure of his trembling fingers. He activated the units, and they reached with invisible speeding fingers across space, guided unerringly by the homing circuits, and grasped a nodule of space, two thousand miles above the Sahara desert on Earth, held fast . . . *and pulled.* The ship whipped into subspace. The ship was homing. Shaeffer slumped more deeply into the seat, completely exhausted, his throbbing, pain-torn body pulling the warm, welcome cover of soft, healing sleep over itself. Shaeffer slept.

At a point precisely one hundred and twenty-five thousand light-years from Earth, and in the direction of the middle button in Orion's belt, but well, well beyond that scattered group of stars that made up the Orion constellation in the home galaxy, an insidious swath of destruction swept out in spherical waves in normal- and subspace with terrifying velocity. A terrible swath of expanding destruction that would in an instant of the Universe's time sweep out of existence a region of space: clusters of galaxies, worlds and civilizations . . . yet only an insignificant portion of the whole magnificent immensity of space and time. The scintillating, radiating dust motes of an alien ship from that doomed region which discovered the impending disaster, dispersed into nothingness in the outward sweep of destruction.

In another four months, the returning *Upper Limit*, with the aid of its unerring mechanisms will surface into normal-space just two thousand miles above the earth.

It will bring home the news of the deadly drive in a quite convincing fashion.



MIND OVER METAL . . .

It's just a bit of cold metal, this piece of printers' type . . . worth about 35¢ a pound. Yet it is the means by which an idea can be put on paper and spread a millionfold.

If America's printing presses were to stop, consider what would happen . . . to our educational system . . . to commerce . . . culture . . . communications . . . to civilization itself.

PROGRESS UNLIMITED . . .

We've come a long way from the printing techniques of the early Gutenberg 42-line Bible to the phenomenally fast presses of today. Thousands of craftsmen in the field of graphic arts have contributed to your education, enjoyment and enlightenment. Designers of hundreds of type faces. Researchers in metals, inks, paper and processes. And other skilled craftsmen utilize these materials and processes to bring you the printed word.

The Business Magazines to which men look for help with their jobs are an important segment of America's all-seeing, all-hearing and reporting Inter-Communications System.

THE AMERICAN INTER-COM SYSTEM . . .

Complete communication is the function, the unique contribution of the American business press . . . a great group of specially edited magazines devoted to the specialized work areas of men who want to manage better, design better, manufacture better, research better, sell better, buy better.

WHY WE HAPPEN TO KNOW . . .

The McGraw-Hill business publications are a part of this American Inter-Com System.

As publishers, we know the consuming insistence of editors on analyzing, interpreting and reporting worth-while ideas.

As publishers, we know that advertisers use our business magazines to feature the products and services which they offer in the interest of increased efficiency, and lower production costs.

As publishers, we know that people subscribe to our business publications to keep abreast of what's new in their field and in industry as a whole. For the editorial pages tell "how" and the advertising pages tell "with what."

McGRAW-HILL PUBLISHING COMPANY, INC.

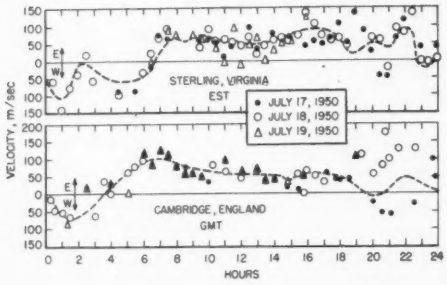
330 WEST 42nd STREET, NEW YORK 18, N. Y.

HEADQUARTERS FOR BUSINESS INFORMATION

briefing the news

Winds in the Ionosphere . . .

One of the causes of fading in radio communications is a wind phenomenon in the ionosphere that closely resembles surface winds. Winds of the upper atmosphere are produced by solar and lunar gravitational tides and by the heating effect of radiations from the sun. Because knowledge of these motions is necessary for correct evaluation of the role of ionization, deionization, and diffusion processes in the upper atmosphere, the National Bureau of Standards has incorporated a study of winds in its ionospheric research program.



NBS observations of ionospheric winds are made on a regular monthly schedule, and the data are coordinated with similar observations made by scientists in Great Britain and in Canada. The good agreement that has been obtained between the records of the three participants suggests the possibility that the observed winds belong to a world-wide circulatory system of the outer atmosphere.

Analysis of the results indicates that the azimuths of the winds are subject to seasonal variations. During June, July, and August the winds blow principally to the east. In December, January, and February the wind direction is generally southwesterly. During the spring and fall, the winds often appear to rotate in a clockwise sense, completing two complete rotations in a 24-hour period. The wind speeds are also subject to variations; some are as high as 300 m/sec (660 mph), but the average is about 70 m/sec (150 mph).

In the past, ionospheric-wind characteristics have been calculated from observations of slowly drifting meteor trails and luminous clouds occasionally seen during the night hours. However, because the data are derived from relatively rare phenomena, this method is not capable of giving a comprehensive picture of upper atmosphere winds. At present a systematic technique that takes advantage of the reflecting property of the ionized layers of the upper atmosphere, upon which all long-distance radio propagation depends.

When radio waves of constant amplitude are reflected from the ionosphere back to the earth, they usually return with an amplitude that varies erratically with time. The variation or fading of the radio signal is generally a nuisance factor in long-distance communications but aptly lends itself to an investigation of ionospheric winds.

If the fading is observed at two receiving antennas separated by one or two wavelengths of the probing radio waves the fading patterns are very similar, but often appear displaced in time. This time delay can be explained by assuming that the ionosphere is made up of patches of ionization; in other words, some parts of the ionosphere are more densely ionized than others. For this reason, the radio waves that are scattered or reflected from the ionosphere produce a "diffraction pattern" of signal intensities on the ground. Thus, as the overhead layer of the ionosphere moves, the ground pattern also moves and the fading sequence appears first at one antenna and then the other. The amount of time delay between the arrival of various parts of the fading pattern at the two antennas will depend on the speed of the movement. The direction and speed of the motion can be determined by using three antennas located at the corners of a triangle and employing triangulation principles. The ground pattern moves twice as fast as the ionosphere irregularities which give rise to it.

The ionospheric wind equipment consists of a transmitter operating at 2.3 MC and three receiving antennas and their associated radio receivers. The transmitter produces 200-microsecond pulses with a peak power of 10 kilowatts at a rate of 60 per second. The receivers are gated to respond only to those pulses that have been singly reflected from the ionosphere (single-hop reflection). The output of each receiver is recorded on paper tape as a function of time.

Cold Extrusion of Steel . . .

In a highly important metallurgical development, steel now can be pushed rapidly through a die, while cold, to form cylindrical products. Contrary to beliefs that steel required heat for such operations, cold extrusion has been found possible under certain conditions — with giant power. New developments in dies and lubricants make it possible, with discoveries of the plastic nature of cold steel whereby the metal can be made to flow rapidly.

Extrusion is a process by which pressure pushes a material through a die in contrast with drawing, which pulls a metal through, exerting a stretching stress. High pressure and confinement make the metal ductile or plastic. Softer metals have been extruded for many years.

For cylindrical shapes, such as artillery shell cases and shock-absorber parts, it is asserted by advocates of cold extrusion that it gives cold worked properties to the steel, saves machining, gives a smooth surface and wastes very little metal.

Hot Stuff Now Seen . . .

Deadly radioactive materials, hidden behind a thick concrete wall, can now be safely studied and photographed under a microscope by atomic scientists, using a new instrument jointly announced by American Optical Company's Instrument Division, at Buffalo, N. Y., who built the device, and the General Electric Company.

First of its kind, the instrument is being installed in the Knolls Atomic Power Laboratory, operated by General Electric for the Atomic Energy Commission. The instrument is expected to make possible investigations that have never before been accomplished on the effects of radiation damage to materials. It is a special microscope for examining the structure of

metals, combined with camera, periscopes and an illuminating system, in such an arrangement that light can get in and out through the thick walls of the test chamber, but dangerous radiations from the radioactive specimens are completely blocked.

Operated by remote control, the instrument permits atomic researchers to work in complete safety. Some sort of remotely controlled "mechanical hands" could be used to place the specimens in position and to remove them after examination.

Light for illumination of the specimen comes from an arc lamp outside the thick-walled test chamber, and goes into the chamber through a lens system placed in a tubular hole through the wall. The light is reflected from the specimen, and comes out again through another series of lenses, to form the magnified image.

Both lens systems are offset by means of mirrors, which change the light path from horizontal to vertical, and then back to horizontal again. Radioactive radiations from inside the test cell are not reflected and cannot get around the offset. If the tube were straight, however, they might be able to emerge through the opening for the lenses.

In using the microscope, which extends into the test chamber, the specimen is put into place on the microscope stage. Looking through a single eyepiece, the operator employs the remote controls to get the specimen adjusted and properly focused. Then the visual eyepiece is exchanged for a photographic one, and the camera is swung into position to make the photograph.

At the lowest power, the instrument shows the specimen in its actual size, without any magnification, whereas 1,000 diameters magnification may be obtained with the highest power. These different powers are achieved by the use of several objective lenses for the microscope, which are mounted on a revolving turret and can be swung into place, again by remote control, as desired. The objectives are so adjusted that it is not necessary to refocus when changing from one power to another.

Polarized light, consisting of vibrations in a single plane, as opposed to ordinary light in which the vibrations are in many different directions, is invaluable in the study of metals, and may also be used. This is made possible by a light-polarizing slide in the path of light from the illuminator. By remote control the slide may be put in or out of position as desired.

The new microscope will shortly be in operation.

Electric Squeeze . . .

A special electric drive, largest of its kind, is being built by General Electric Company for a giant rolling mill that holds a world record for squeezing five-ton blocks of white-hot steel into long bars, called "blooms."

Designed to keep pace with the demands of a steel-hungry defense effort, the equipment will constitute the nation's most powerful reversing mill drive for converting ingots into blooms. It will include twin 6,000-horsepower motors, each of which will drive one of the mill's two huge pressure rolls.

Steel ingots, five-foot-long masses of metal weighing as much as three medium-sized automobiles, are heated to 2200 degrees F. as raw material for the mill. As an ingot passes back and forth between the rolls, it is reduced to a bloom more than 50 feet long and seven inches in width and thickness. These blooms are later rolled into steel products in the various finishing mills.

The main drive motors for the mill will be provided with amplidyne control for near-instantaneous acceleration, deceleration, and reversing of the rolls. This control will permit the mill to reverse in approximately one second.

Providing power to the motors will be a 12,000-kilowatt motor-generator set, which includes a 91½-ton flywheel. The flywheel, one of the largest ever built, will be nearly 16 feet in diameter and two feet thick. Its stored energy will be equivalent to that of the full 15-car Twentieth Century Limited traveling at 40½ miles per hour. The flywheel releases portions of this energy through generators to the drive motors to reduce peak demands on power-supply lines.

To insure against breakdown in the blooming mill's 160-hours-a-week work schedule, equipment will be so installed that near-peak performance can be obtained even when portions of the apparatus are out of service. The changeover from steam to electric drive is expected to be completed early in 1953.

Radiation Lampshade . . .

A "radiation lampshade," so-called because it resembles a lampshade, and designed to determine quickly and accurately the position of an atomic bomb explosion, was described recently by a General Electric scientist.

It is made of sheet metal, about a foot in diameter, smaller at the top than at the bottom, and painted white inside and out. On the inside surface are numbered vertical lines and lettered horizontal lines. A pointed brass rod projects upward inside the device. The instrument as such would be mounted out-of-doors, so that it would be exposed to radiation.

During an atomic bombing, intense heat radiation would scorch the inside painted surface in relation to the direction of the burst from the location of the device. Because the heat radiation, like light, would travel in straight lines, it would form shadows of objects in its path, and thus shadows of the upper edge of the device and of the pointed brass rod would appear as unscorched areas on scorched regions. The positions of the shadows as determined by the numbered vertical lines and lettered horizontal lines would furnish evidence of the direction and height of the bomb burst.

The radiation lampshades would be located so that at least four would be within one to two miles of any burst. Wardens would inspect them immediately after an explosion and report the letter and number of the lines where the shadows of the upper rim and point fall, thus giving the direction and altitude angle of the burst. With two or more such reports, a headquarters unit could determine ground zero and the height of the explosion.

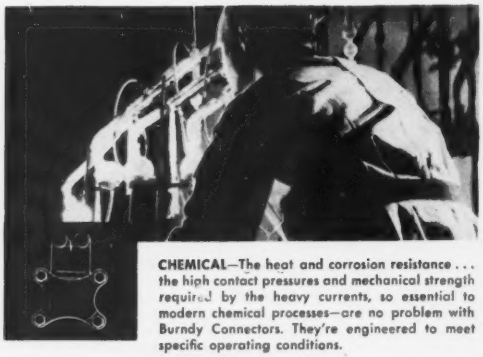
Atomic Power Still Remote . . .

Despite intensive work of the last five years on development of atomic energy as a source of power, the economic aspects of such power are still not clear, a General Electric engineer, active in this work, declared recently. He said that all that has been written about the economics of nuclear power has necessarily been based upon very nebulous information.

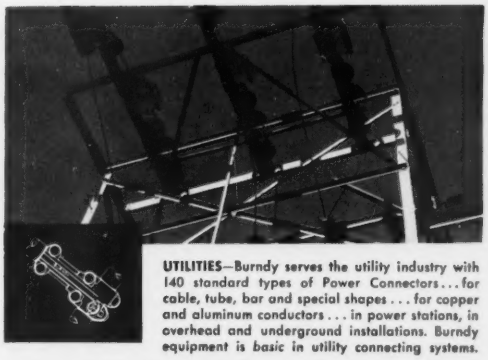
Many more years of work will be required before these economic factors are fully understood. For some years to come it is certain to be an expensive source of electric power which will not compete with conventional fuel, except in certain specialized fields where advantage may be taken of its unusual properties.

(*Continued on page 50*)

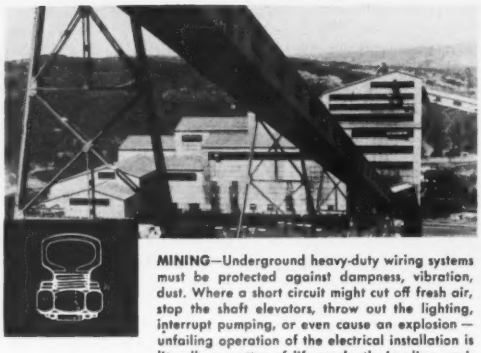
Wherever there's electricity... you'll find Burndy connectors on the job!



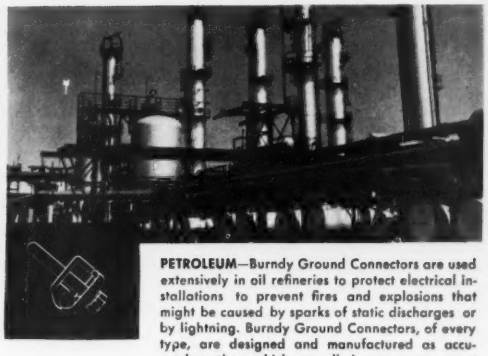
CHEMICAL—The heat and corrosion resistance . . . the high contact pressures and mechanical strength required by the heavy currents, so essential to modern chemical processes—are no problem with Burndy Connectors. They're engineered to meet specific operating conditions.



UTILITIES—Burndy serves the utility industry with 140 standard types of Power Connectors . . . for cable, tube, bar and special shapes . . . for copper and aluminum conductors . . . in power stations, in overhead and underground installations. Burndy equipment is basic in utility connecting systems.

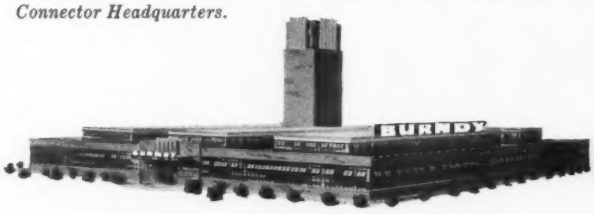


MINING—Underground heavy-duty wiring systems must be protected against dampness, vibration, dust. Where a short circuit might cut off fresh air, stop the shaft elevators, throw out the lighting, interrupt pumping, or even cause an explosion—unfailing operation of the electrical installation is literally a matter of life or death. Leading engineers specify Burndy Connectors.



PETROLEUM—Burndy Ground Connectors are used extensively in oil refineries to protect electrical installations to prevent fires and explosions that might be caused by sparks of static discharges or by lightning. Burndy Ground Connectors, of every type, are designed and manufactured as accurately as those which are called on to carry current continuously.

Burndy Connectors are specified because of their superior performance in joining, terminating, clamping, and grounding every size and functional variety of electrical conductor—from the smallest home wiring circuit to the largest industrial installations. Burndy engineering is continuously developing more and more efficient connecting methods. *Engineering graduates and students are welcome visitors at Burndy Connector Headquarters.*



BURNDY

BURNDY ENGINEERING COMPANY • NORWALK, CONNECTICUT • BURNDY CANADA LTD., TORONTO, ONT.
WORLD'S LARGEST MANUFACTURER OF ELECTRICAL CONNECTORS

"On Target" Today demands electronic computations

Today's gunnery is a far cry from the days of slugging it out at close range — it demands split-second solutions to constantly varying, increasingly complex mathematical problems. Only continuous engineering advances in electronic instrumentation can accomplish this feat.

Thirty-four years of outstanding engineering design and precision manufacture have gone into Arma's leadership in this vital supply link to our nation's Armed Forces. Through specialized knowledge in electronic instrumentation, in the years to come Arma will contribute even more significantly to our *industrial and military might.*

This booklet — "Engineering at Arma" — emphasizes the importance of engineers, physicists and mathematicians at Arma. You may find it the prologue to your career. Write for your copy to Engineering Division, Arma Corporation, 254 36th Street, Brooklyn 32, N. Y.

ARMA CORPORATION
254 36th Street, Brooklyn 32, N. Y.
SUBSIDIARY OF AMERICAN BOSCH CORPORATION

QUALITY ARMA PRECISION
INSTRUMENT

PIONEERING IN INSTRUMENTATION FOR 34 YEARS

briefing the news

(*Continued from page 47*)

Three such properties are cited. One is that a very small amount of nuclear ("atomic") fuel will yield enormous quantities of energy. This, as well as the fact that the energy may be released without oxygen, which is required for burning ordinary fuels, makes it particularly suitable for propulsion of submarines, he said.

In addition, with nuclear fuel it is theoretically possible to produce energy of commercial value and at the same time to "breed" new or secondary fuel which would have military value. This feature may offer the best opportunity for the first economical large-scale generation of electrical power of nuclear origin.

Primer Bond . . .

A method of joining silicone rubber to steel and other surfaces in a permanent bond stronger than the rubber itself has recently been discovered.

Key to the process is a thin, glue-like "primer," which forms a strong bond between silicone rubber and many surfaces besides steel, including glass, ceramics, aluminum, tin, and copper, according to research chemists. Development of the primer increases the usefulness of silicone rubber in structural combination with metals, it was pointed out.

Typical applications would include engine and shock mounts. Engines mounted on silicone rubber would produce greatly reduced vibration. Delicate aircraft instruments similarly mounted would be less subject to damage by severe wind buffeting of aircraft or shock in landing. Heavy-duty washers or gaskets made of tough glass fibre bonded between layers of silicone rubber may also find industrial application.

To produce the bond, the liquid primer is brushed or sprayed on the metal or glass surface to be joined to silicone rubber. After drying, the surfaces are placed together under light pressure at about 250 degrees Fahrenheit. The resulting bond withstands temperatures from 85 degrees below zero F. to 500 degrees above zero F. In laboratory experiments, the bond has shown a strength of about 700 pounds per square inch of holding area.

"Vest-Pocket Atomic" Oven . . .

The development of a "vest-pocket" atomic reactor was announced recently by North American Aviation, Inc.

The "oven," 19 feet in diameter and 11 feet high, will produce energy at a constant rate of 160 kilowatts — comparable to 1,000 electric toasters operating simultaneously. It was devised under contract with the AEC.

The reactor is not a power generator. It is intended for such purposes as producing radioactive chemicals and streams of neutrons for medical radiation treatments.

The significance of the development is that for a comparatively small sum — an estimated $1,000,000 — any organization can have a facility providing, for ordinary civilian purposes, the radiological materials now available only on a limited basis from the atomic installations at Brookhaven and Oak Ridge.

This reactor potentially can make available in all parts of the country radioisotopes which now cannot be supplied to distant sections such as the Pacific Coast because, radioactively speaking, they decay so fast. For example, sodium-24 is half exhausted, radioactively, in 14.7 hours, precluding packing and shipping it very far.

The design, it was announced, will eventually be made available through the Atomic Energy Commission to any organization that wants to build one of the reactors.

New Surfacing Method . . .

Ordinary water in which extremely fine abrasive dust is suspended may be used for producing high finishes on both metal and non-metallic products.

In this process, liquid is sprayed under high pressure. Abrasives as fine as talcum powder and even finer are used, suspended in a liquid (usually water and a corrosion preventive) and the liquid is driven against the part to be finished by high pressure air. Impact of the particles removes minute amounts of metal from the surface and leaves it clean and with an attractive appearance.

Actually, the surface after liquid impact blasting is covered with millions of microscopic "pockets." On working surfaces, these hold oil and improve the operation of the part and its life. In addition, the surface has a pleasing, non-glare appearance.

It is also useful on instruments and tools. Cutting tools last longer if they have been liquid-impact blasted. The operation has the same effect as if a machinist carefully honed the cutting surface by hand.

Besides small machines for use in tool rooms, machines have been built to automatically remove heat-treat scale and improve the finish of 700 automotive ring and pinion gears per hour.

Shockproof Aircraft . . .

High-precision controls and other devices for jet aircraft of the future may be nearly shock-proof as a result of a new "center-of-gravity" type mounting.

The new mount, designed to isolate the controls from vibration and shock encountered in modern high-speed aircraft, was developed by General Electric Company engineers. It resembles a small platform suspended by a coil spring at each of its four corners.

Key to its effective operation is the location of the control to be protected. The control is placed on the mount so that its center of gravity is an equal distance from each of the four supporting springs, and in the same geometric plane. This eliminates unbalanced movement and enables the springs to withstand shock from any direction.

In addition, each spring is constructed of metal layers of different thicknesses. These layers have widely differing reactions to vibration so they tend to "snub" or neutralize one another and thus eliminate resonant vibrations.

In their first use in aircraft, the new mounts will carry voltage regulators, which maintain a constant output of electric power for the plane's generators.

About the size of a box camera, a voltage regulator weighs 3½ pounds when at rest. Under shock conditions, however, this weight is multiplied greatly as forces equal to ten times the earth's gravitational pull are exerted. This much force might be encountered in extreme shock during landing, pulling out of a steep dive, or in a sharp turn.

L&N instruments "From Coal Pile to Bus Bar" in central station's control room
Electro-chemograph
Speedomax control on annealling furnace
Speedomax control of ceramic kiln temperature
Research with K Potentiometer & accessories
Homocarb furnaces in auto plant
Aircraft testing
Speedomax controllers & recorders in petroleum refinery

LOOKING FOR OPPORTUNITY? LOOK AT L&N!

Because instruments are basic both to industrial and to scientific work, the instrument field ranks high in opportunity. As long as men make pig iron or pills, guns or butter, clothing or kilowatts or gasoline, industry will use more and more instruments on the production line. As long as scientists "unscrew the inscrutable" they will need instruments for laboratories, defense projects, and industrial research.

As a result, L&N job opportunities are quite varied. The openings in sales engineering utilize technical training in the examination of processes, and in selection and application of correct instruments in industrial plants. Other openings are in research and still others in engineering development of L&N products. Also beckoning are production, advertising, inspection and other operations.

We make automatic, balance-type electrical instruments for controlling, measuring and indicating temperature, chemical concentration, combustion, frequency & load, flow and other conditions. We make heat-treating process equipment complete. We make laboratory-type instruments in forms for scientists from freshman to Ph.D.-plus.

Our chosen portion of the automatic control and instrument field is in high-precision, high-dependability equipment. Commercially, we are one of the leaders; we have grown in every decade of our history, and continue to grow. And we are innovators; we pioneered many basic developments . . . are pioneering others, and will continue to do so.

Personnel-wise, the Company's policies are modern and progressive. We have long had group insurance, hospitalization, pensions and financial assistance for post-college education. Compensation includes profit-sharing as well as salary. L&N will continue to offer present opportunity and a substantial future.

If you have good grades in engineering or in a science major, and a good general record, we will welcome the opportunity to discuss a specific opening with you. As a starter, just check below the activity you prefer and mail the coupon to us.

Field of Work	COLLEGE COURSE						
	Elec. Engrg.	Mech. Engrg.	Ind'l. Engrg.	Chem. Engrg.	Met. Engrg.	Physics	Chemistry
Engineering							
Research							
Sales Engrg.							
Advtg.							
Mfg.							

Name_____

Course_____

Street_____

City_____ State_____

LEEDS & NORTHRUP CO.

INSTRUMENTS • AUTOMATIC CONTROLS • FURNACES
4915 STENTON AVE., PHILADELPHIA 44, PA.

Atlanta Boston Buffalo Chicago Cincinnati Cleveland Detroit Hartford
Houston Los Angeles New York Pittsburgh San Francisco Seattle St. Louis Tulsa

Agents in Principal Countries

Jrl. Ad ENT(13)

Growth means OPPORTUNITY

To the young man looking for opportunities, the present size of any company is less important than its rate of growth.

In a progressive, expanding company such as Columbia-Southern, men move ahead and are upgraded to fill new positions created by plant expansion, new departments, new facilities, and the introduction of new products. This is in contrast to static companies where advancement is dependent largely on vacancies occurring through death or retirement.

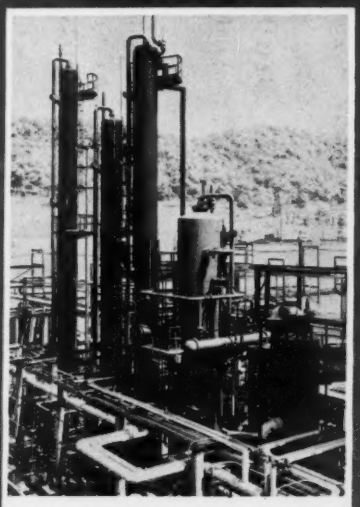
Columbia-Southern, a leading alkali producer for over half a century, has expanded in recent years, to organic chemicals including chlorinated benzenes. It has recently completed a million dollar plant for the manufacture of perchlorethylene and a multi-million dollar expansion program in a group of new and exclusive rubber pigments. Vast research, development and commercial production in agricultural chemicals are now important parts of its program.

Numerous other expansions have taken place. Monthly sales during 1951 were five times as great as in 1941.

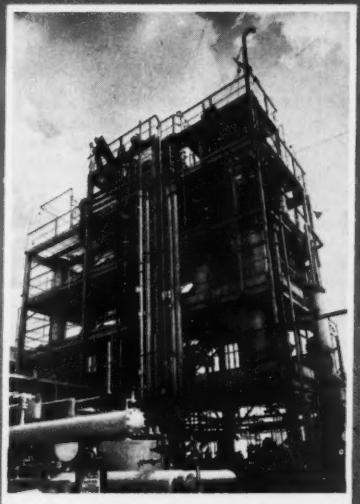
Columbia-Southern's broad program affords opportunities to today's young men in varied technical fields including chemical engineering, design, sales, construction, maintenance, power, production, supervision, research and development, traffic, purchasing and accounting.

At Columbia-Southern the ultimate advancement of any graduate engineer does not require a specific type of technical training. Actually, a variety of technical degrees is represented in the top executive posts throughout the company.

Look into the opportunities at Columbia-Southern. Write today for additional information.



Section of Columbia-Southern's recent installation for the production of Chlorinated Benzenes.



Portion of Columbia-Southern's new million-dollar Perchlorethylene plant.

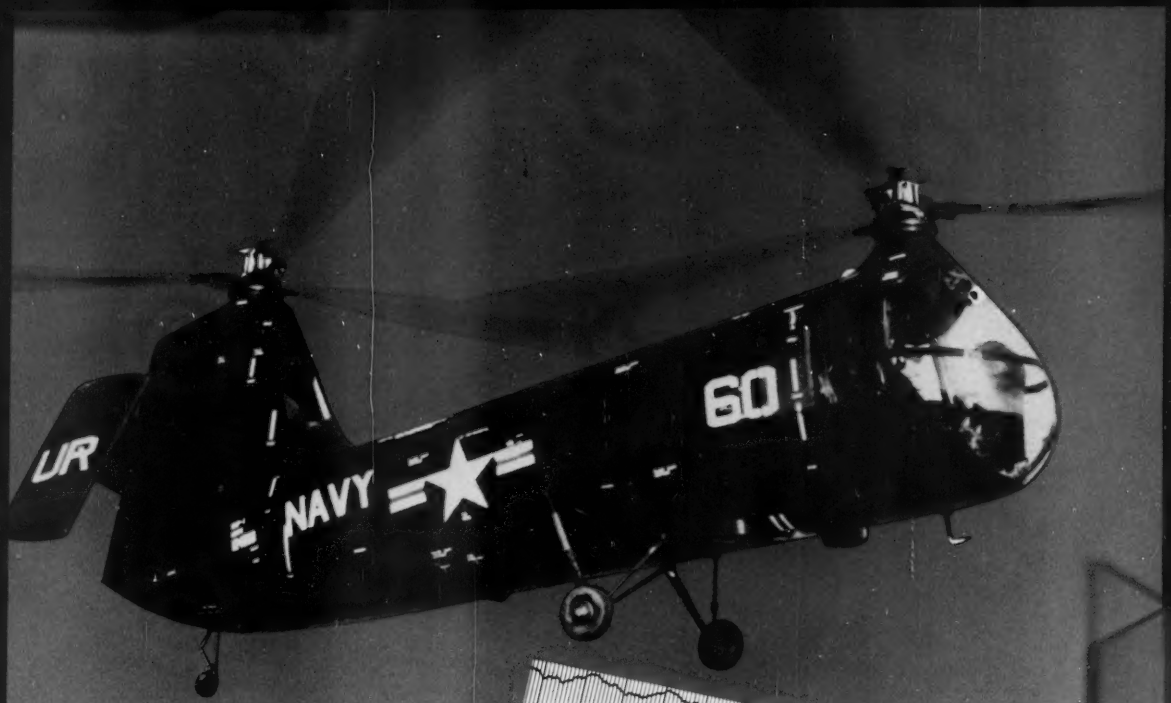
COLUMBIA-SOUTHERN CHEMICAL CORPORATION

SUBSIDIARY OF PITTSBURGH PLATE GLASS COMPANY

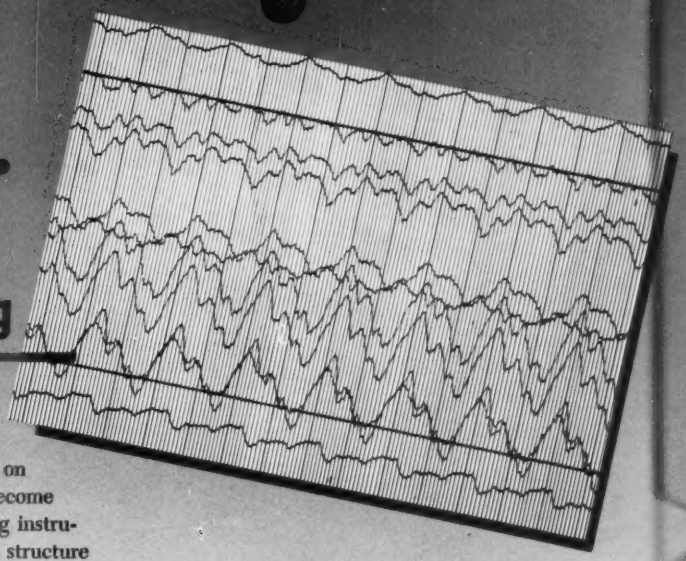
FIFTH AT BELLEFIELD, PITTSBURGH 13, PA.

PLANTS: BARBERTON, OHIO; BARTLETT, CALIFORNIA; CORPUS CHRISTI, TEXAS; LAKE CHARLES, LOUISIANA; NATRIUM, WEST VIRGINIA

DISTRICT OFFICES: BOSTON, CHARLOTTE, CHICAGO, CINCINNATI, CLEVELAND, DALLAS, HOUSTON, MINNEAPOLIS, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURGH, ST. LOUIS



Photography... an able helper all through engineering



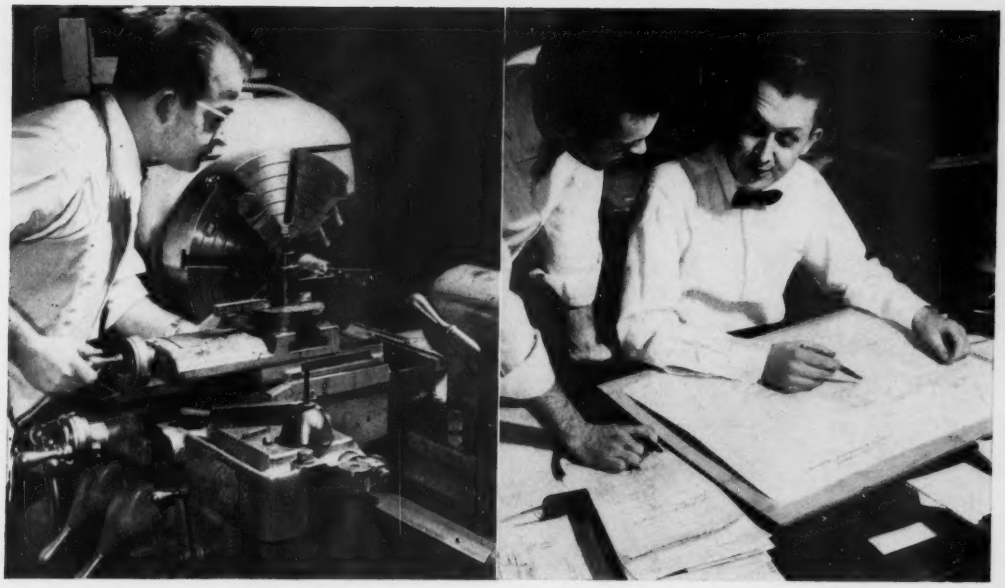
These traces provide helicopter engineers with information about blade stresses during flight. Strain gages pick up bending at different locations. Photography with its perfect memory catches the whole story as fast as it happens.

In the laboratory, in the drafting room, on the production line, photography has become a most important tool. It records fleeting instrument traces for study. It examines metal structure through electron micrography, x-ray diffraction, and microradiography.

The use of photography in engineering, business, and industry is increasing steadily. This has led graduates in the physical sciences and in engineering to find positions with the Eastman Kodak Company. If you are interested, consult your placement office about arranging an interview with an Eastman representative, or write direct to Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, N. Y.

FUNCTIONAL PHOTOGRAPHY
serves industrial, commercial, and scientific progress

Kodak



The Program includes assignments in machine operation and production functions.

Introducing

THE NEWEST MEMBER OF THE G-E TRAINING FAMILY

A Program for Developing Manufacturing Leaders

At General Electric, with its 200,000 products, millions of dollars must be spent annually for materials alone . . . and more than 100,000 people in 119 plants comprise its manufacturing organization.

WHAT MANUFACTURING IS

Manufacturing comprises all the activities essential to translating engineering designs into finished products.

This means that there are satisfying, rewarding careers in manufacturing supervision and as technical specialists in such important areas as purchasing, manufacturing engineering, production, and wage rate work, and in the specialized functions within each one. These include technical specialties: value analysis, materials handling, operation planning and methods analysis, inventory control, and motion time study.

Men holding such jobs are finding them challenging because of the skills, imagination, and understanding they require . . . are finding them rewarding in professional prestige and personal achievement.

AIMED AT THE NEED

To train men for such positions is the objective of the Manufacturing Training Program, newest member of the well-known group of comprehensive Company-wide training programs—Test, Chemistry and Metallurgy, Physics, Business Training, and Advertising.

At the conclusion of the Program, members fit into some phase of General Electric manufacturing, with their on-the-job progress being carefully followed to assure the most effective utilization of their skills. Recently, our G-E manufacturing groups surveyed their future leadership requirements. Within the next five years, their needs for new leaders in direct supervision alone will exceed 1300 men!

OPPORTUNITY . . . AND YOU

If a career in manufacturing at General Electric interests you—and if you have a technical education or a general education with marked technical emphasis—talk with the General Electric representative when he visits your campus. Meanwhile, send for our booklet that describes G-E manufacturing and the program in detail. Please address your request to Dept. 283-23, General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

407-27C